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2nd Ser. BOTANY.] [VOL. VI. PART 1.

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REPORT ON TWO BOTANICAL COLLECTIONS MADE BY MESSRS. F. V. McCONNELL AND J. J. QUELCH AT MOUNT RORAIMA IN BRITISH GUIANA.

BY

N. E. BROWN, A.L.S., & OTHERS.

(*Communicated by* Sir W. THISELTON-DYER, K.C.M.G., F.R.S.)

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January 1901.

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I. *Report on two Botanical Collections made by* Messrs. F. V. McConnell *and* J. J. Quelch *at Mount Roraima in British Guiana. By* N. E. Brown, *A.L.S., and others.* (*Communicated by Sir* William Thiselton-Dyer, *K.C.M.G., F.R.S., F.L.S., Director of the Royal Botanic Gardens, Kew.*)

(Plates I.–XIV.)

Read 15th March, 1900.

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INTRODUCTION.

By I. H. Burkill, M.A., F.L.S.

In the autumn of 1894 Messrs. F. V. McConnell and J. J. Quelch first visited Roraima; they were there again in the autumn of 1898, and on both occasions not only encamped higher on the slopes of the mountain than any previous traveller, but they spent nights on the summit in order that the time given to collecting its flora and fauna should be uninterrupted. The collections of plants were transmitted to Kew, and both are enumerated in this paper.

In 1894 the journey to Roraima commenced (October 16) at Kwaimatta, a village on the open savannah to the south-east in latitude 3° 50′ N. The Ireng was crossed at the Karona Falls, the Kotinga at Sokoking, a ford not named on the older maps, but situated a little to the south of the meeting of the Kotinga and Karakanang streams. Thence the way led into the Arabapu Valley (November 3), on the north and west sides of which rise the slopes of Roraima. The return journey was commenced on November 11, and the route taken crossed the Kotinga nearer its source at Orinidoui (apparently the "Orinidouk" of the old maps), and the Ireng again at the Karona Falls.

In 1898 the journey was commenced (August 20) on the lower Mazaruni River. The great bend of this river, where the Peaiman Falls occur, was avoided by a porterage from the Kurubung Creek to the upper Mazaruni, which was again left by the Kako River; the Kako was paddled up until a point was reached about twenty miles north-east of Roraima, and thence, leaving the canoes, a track through dense forest was taken until, in the second week of October, the south-eastern face of the mountain was reached. Roraima was left again at the end of October, and the way retraced to the lower Mazaruni.

Three days in 1894, nine in 1898, were spent in making collections upon the broken plateau which forms the summit of Roraima.

VISITORS TO RORAIMA.

	Year.	Month.	Height reached.	Route to Roraima.	Return Journey.
R. H. SCHOMBURGK	1838	Nov.	Base of Mountain.	From S. over Humirida Mtns.	Retraced steps.
R. H. and RICHARD SCHOMBURGK.	1842	End Oct. to Dec. 5. End Oct. to Nov. 22.	Base of cliff on S. side.	ditto.	At first S., then to W. of Roraima. Retraced steps.
KARL APPUN	1864	End Jan. to end Feb.	Base of cliff on E. and S. sides.	From N. over Merume Mtns.	Towards S.E. to Pirara.
C. B. BROWN and J. G. SAWKINS.	1869	Early Feb.	Upper slopes.	From S.E.	
J. W. BODDAM-WHETHAM and M. MCTURK.	1878	March.	ditto.	From N. over Merume Mtns.	Retraced steps.
D. BURKE	1881	....	ditto.		
SIEDEL	1884	Feb. to Apr. and Nov.	ditto.	From N.	
E. F. IM THURN and H. I. PERKINS.	1884	Nov. to Dec.	Summit from the S. side.	From R. Potaro to Ireng, then to Roraima from S.E.	Retraced steps.
E. KROMER	1886	Nov.	ditto.		
DRESSEL	1887	Oct.	ditto.	From N. over Merume Mtns.	
F. V. MCCONNELL and J. J. QUELCH.	1894	Nov.	ditto.	From S.E.	To S.E. by a somewhat parallel track.
F. V. MCCONNELL and J. J. QUELCH.	1898	Oct.	ditto.	From N. over Merume Mtns.	Retraced steps.

Appearance and Structure of Roraima, and its Geographical Relations to the Mountain-systems of South America.—Im Thurn and Perkins, who made the first ascent on December 18, 1884, reached the top under unfavourable conditions: they had ascended that day from their base-camp at 5400 feet, and only reached the summit in the afternoon, when clouds almost invariably envelop it; they had no means of remaining there, and were forced to return after a very short stay of three hours. Perkins speaks of these clouds as impenetrable (Proc. Roy. Geogr. Soc. vii. 1885, p. 532) *; at all events they limited the range of exploration, and the report was made that "the vegetation on the summit is extremely scanty and insignificant, there being no trees, only small bushes from three to six feet in height, growing at long intervals." It has been reserved for McConnell and Quelch to ascertain that there exist in favoured places trees which attain a height of no less than forty feet.

Of the ascents of Dressel and Kromer I can glean no more than is in a brief notice in 'Timehri,' 1887, p. 330. Neither can have remained on the summit for more than a few hours.

The features of this summit are:—Blackened elevated ridges, irregularly terraced and rugged; winding gullies which drain away the superabundant rain through shallow pools; patches of sand in their shelter with isolated small bushes; clumps of vegetation lodged in the most protected spots; piles of wind-cut rocks without a sign of plant-life, rising into pinnacles; no soil; the keen northerly wind, and mists which gather at least after noon on almost every day in the whole year. The highest pinnacle rises to 8740 feet; the deepest gully may be 400 feet below it.

The known sides of the mountain which face north-east and south-east, produce rocky savannah up to 5000 or 5400 feet, the rocks so numerous that Appun likens the country to a grave-yard; then forest to 7100 feet, dense below but stunted and more open above; and from this altitude rise the precipitous cliffs, which give to the whole the appearance of a vast fortress with a tree-clad glacis slope.

These precipices were deemed impossible of ascent by the travellers they had baffled until Whitely indicated, and im Thurn showed practicable, the one known ledge leading to the summit.

The rock is a quartzose sandstone interbedded with diorite. The topmost and thickest bed of diorite comes to the surface where the dense forest is; the lower beds make a series of terraces down the lower slopes. These beds lie perfectly horizontal without folding or other sign of any great disturbance. Diorite lends itself to the formation of a soil †, the sandstone does not.

Such sandstones as constitute Roraima have a very wide extension in South America; they pass eastward into Surinam; Duida is made of them; they form the bed-rock of the llanos of Venezuela, and appear in the Caripe mountains to the east of Caracas; in Brazil the area occupied by them is immense.

---

[*] *Cf.* im Thurn in 'Timehri,' 1885, p. 41.

[†] The Indians prepare their provision-grounds on the diorite (see Brown & Sawkins, Reports, p. 17), and those living under the south-eastern face of Roraima have placed them far up the sister-mountain of Kukenaam, where the diorite comes to the surface (Quelch, in 'Timehri,' 1895, p. 164).

All this sandstone area belongs to the oldest land of South America: against the edge of it the Andes were heaped up—newer land which grew to its present form in the tertiary period, and formed a link of high ground round the head of the then existing Amazon valley.

It is significant to us that the chief mountain-systems of South America outside the Andes reach very similar heights and similarly stand more or less parallel to the nearest coast, whence the trade-winds bring an abundance of rain. These mountain-systems are three: (1) the Coast Andes of Venezuela, of direct eruptive origin, but continued eastward from Caracas in the lesser sandstone mountains of Caripe; (2) the Parime mountains with Roraima at the eastern end and Duida at the western end; and (3) the mountains of South Brazil formed of schists tipped at a high angle.

Heights north of the Equator.*

Coast Andes.		Parime Mountains.	
Niaguata	9125 feet.	Roraima	8740 feet.
Silla of Caracas	8741 „	Duida	8278 „
Tamaya	8052 „	[Peaks near Duida estimated at 10,000 feet.]	

Heights in South Brazil.*

Itatiaia	8999 feet.	Itambe	5960 feet.
Organ Mountains	6609 „ and more.	Serra da Piedada	5874 „
Serra da Caraça	6411 „	Itacolumi	5760 „

Unlike in geological structure the three systems are unlike as well in their relation to the Andes. The Casiquiare, by uniting the Orinoco and Amazon, encircles the Parime mountains, and the undulating country of little elevation to the west of it effectually separates this system from the Andes; the plains of Matto Grosso, &c., wherein rise within a few miles of each other the Paraguay and Madeira, to flow the one north, the other south, separate the Brazilian mountains and the Andes; but the Venezuelan coast-range is most intimately bound to the Andes proper through the Cordillera of Merida.

Spanish settlers in the New World soon came to recognize a belt on the mountains of the tropics suited to their needs and for the growth of their food-plants. They called it the temperate land—"tierra templada,"—and the range of its mean annual temperature may be set down as 15°–20° C. (59°–77° F.). Above the "tierra templada" is the "tierra fria," below it the "tierra caliente."

The limits of these belts depend on exposure. In the Venezuelan mountains, according to Sievers ('Venezuela,' p. 26), the "tierra fria" extends from about 7200 feet upwards; among the Great Andes it sometimes commences as high as 10,000 feet; on Roraima it descends presumedly into the forest-belt or to the base of the cliffs *. Roraima bears the most eastern patch of "tierra fria" upon the northern side of the Amazon.

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* The heights of the Coast Andes are taken from Sievers's 'Venezuela' (Hamburg, 1888), pp. 277, 278; those of Duida and neighbouring peaks from Sir Robert Schomburgk's narrative in Proc. Roy. Geogr. Soc. x. 1840, p. 245; and those of the Brazilian mountains, Itambe excepted, from Liais, 'Climats, Géologie, Faune et Géographie botanique du Brésil' (Paris, 1872), pp. 45–49. Most astounding are the erroneous statements published regarding the altitudes of the Brazilian mountains; for instance, the Serra dos Pyrenaos, estimated previously to reach 9700 feet, proves to be no more than 4543 feet (Cruls, 'Relatorio da Commisão exploradora,' Rio, 1894, p. 26).

Some hundreds of feet above the commencement of the "tierra fria" is the limit of trees. There are reasons for believing that both the Coast Andes and Roraima just reach this limit; they do not distinctly rise above it.

The Flora.—Passing on to a consideration of the nature of the flora of Roraima I have given in the table on pp. 8–16 as complete a list as is now possible of the species found on the mountain above 5000 feet, and we have in it:

239 Spermatophyta, of which 121 (50·6 per cent.) are endemic.
88 Pteridophyta, of which 16 (18·2 per cent.) are endemic.
63 Bryophyta, of which 15 (23·8 per cent.) are endemic.
11 Thallophyta, of which 3 (27·3 per cent.) are endemic.

The proportion of endemic Spermatophyta may seem large, but does not exceed that on record for some of the mountains of Mexico. Of far greater interest is the number of endemic genera. The law that mountains by their isolation and extension, as well as by their latitude, produce endemic genera, is illustrated by their number in the ranges of Cis-equatorial South America; thus, there are eleven among the Spermatophyta on Roraima, and only two on the Coast Andes, which are comparatively small and not isolated; but I am aware of no fewer than thirty-six in the extensive Andes of Colombia, including with them the Cordillera of Merida.

The endemic genera of Roraima are enumerated on p. 7. They belong to as many orders. One of them—*Heliamphora*—has no kindred in South America, but belongs, like *Cyrilla*, to a North-American group; all the rest have more or less close allies in genera of the South-American continent. *Ledothamnus*, however, deserves further remark because it is one of the very few Ericaceæ with ericoid leaves which exist in the New World.

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* This belief is based chiefly upon the nature of the flora. With regard to temperature the following may be added:—Hann ('Handbuch der Climatologie,' Stuttgart, 1883, p. 152), after quoting Boussingault's estimate for the Andes of the tropics that ·57° C. in mean annual temperature is lost for every 100 metres ascended, and Humboldt's for Mexico and Colombia of ·53° C. for every 100 metres, adds: "as a general rule for the tropics one may allow ·58° C. for the amount of heat lost in every 100 metres ascended." This is equivalent to ·4° F. for every 100 feet. As the mean annual temperature of Demerara is 81°, we obtain for Roraima these figures:—65° F. at 4000 feet, 60° at 5400, 53° at 7100, 47° at 8600, and 46° at 8740 feet. The following are all the recorded observations of which I am aware:—

	Night.	6–8 A.M.	Midday and afternoon.
Summit, Quelch in 1894	47° F.	49–52° F.	64°·5 F.
" im Thurn	....	....	54° (in mist).
About 7000 ft., Appun	50°		
About 6400 ft., Quelch	50°		
About 5400 ft., R. Schomburgk ..	52°		
" " " im Thurn	48°		
At the base, R. Schomburgk......	58° and below	62°	87° (shade). 100° (sun).
" " "	58°·5		
" " Brown	....	59°	
" " Boddam-Whetham ..	Below 60°		
" " Quelch	54°		

The endemic genera of the Coast Andes are *Euosmia* and *Caracasia*. *Euosmia*, Humb. & Bonpl., belongs to the Rubiaceæ, and was found by Humboldt and Bonpland in the mountains of Caripe; it is a little obscure and needs re-examination. *Caracasia*, Szyszy. (*Vargasia*, Ernst) is a genus of the Marcgravieæ, with two species found near Caracas; it is nearly related to the genus *Ruyschia*, found in the West Indies and from Guiana to Peru.

Following the list of endemic genera on p. 7 are three lists to be considered together. All are of genera represented in the tierra fria of the Andes: the first contains seven found on Roraima, throughout the Andes to Chili, and in South Brazil; the second contains fourteen found on Roraima and in the Northern Andes, but reaching neither Chili nor the mountains of South Brazil; the third list contains thirteen found in the Andes, which have passed along the Coast Andes to Niaguata or the Silla of Caracas*, but have not yet been found on Roraima.

These lists illustrate two points:—in the first place, they indicate how the Coast Andes belong essentially to the Andes proper,—and the community of genera extends to species in *Cinchona*, *Acæna*, *Cardamine*, and *Berberis*; in the second place, that Roraima and the mountains of South Brazil only have in common among woody plants montane genera so widely Andine as to pass from Colombia to Chili. One is then led to suspect that the mountains near Rio de Janeiro obtained their Andine shrubby genera from the south-west, and that in their case the plains of Matto Grosso have been a very similar barrier to immigration as the wooded hills on the west of the Casiquiare have been to the Parime mountains.

Six more genera are named in a last list; they are common to Roraima and to the mountains of South Brazil, without reaching Chili; but they all descend to low levels in the Province of Alto Amazonas, and obviously are not montane in a restricted sense.

Other genera which cannot be regarded as truly montane, contribute montane forms to the flora of Roraima. The most notable of these is *Abolboda*, of which genus *A. Sceptrum* is by far the largest species.

Saxofredericia regalis is, like *Abolboda Sceptrum*, the largest of its genus. *Lisianthus Elizabethæ* and another species collected under this name by Appun are among the largest-flowered of these gentians; and *Utricularia Humboldtii* so impressed Sir Robert Schomburgk by its showy blossoms as to cause him to name the place where he first saw it the El Dorado Swamp, after the treasure-city Raleigh and others sought in Guiana.

im Thurn has suggested a resemblance between the floras of Roraima and the Brazilian mountains (Trans. Linn. Soc., ser. II. Bot. ii. (1887), p. 257), but the similarities he notes are much more due to similarities of climate than to any evidently intimate relationship between them in times past.

A very rough estimate of the number of genera of Spermatophyta in the flora of British Guiana places the total at 1070. The orders most strongly represented are:—Leguminosæ 86, Orchidaceæ 66, Rubiaceæ 54, Compositæ 44, Gramineæ 43, Euphorbiaceæ 31, and Melastomaceæ 28. On Roraima above 5000 feet, the order

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* Ernst in Journ. Bot. x. 1872, p. 261; in Bull. Soc. Bot. France, xxii. Rev. Bibl. p. 239; in 'Idea general de la Flora de Venezuela' in 'Estudios sobre la Flora y Fauna de Venezuela' (Caracas, 1877), pp. 212–235; and elsewhere.

Endemic Genera (2 occur on the Kaieteur Savannah).

Heliamphora (Sarraceniaceæ).
Leitgebia (Violaceæ).
Blepharandra (Malpighiaceæ).
Crepinella (Araliaceæ).
Chalepophyllum (Rubiaceæ).
Quelchia (Compositæ).
Notopora (Vacciniaceæ).
Ledothamnus (Ericaceæ).
Connellia (Bromeliaceæ).
Nietneria (Liliaceæ).
Everardia (Cyperaceæ).
[***Enterosora*** (Filices)].

Genus found at either end of the Parime Mountains.

Stegolepis (Rapateaceæ).

Genera of the Andes (as regards S. America) extending from the North to Chile, also to Roraima and the Mountains of South Brazil.

Drimys (Magnoliaceæ)
? ***Monnina*** (Polygalaceæ).
Weinmannia (Saxifragaceæ).
Relbunium (Rubiaceæ).
Gaultheria (Ericaceæ).
Pernettya (Ericaceæ).
Puya (Bromeliaceæ).

Genera of the Northern Andes (as regards S. America), not overpassing Bolivia southwards, reaching Roraima, but not South Brazil.

Chætolepis (Melastomaceæ).
Centronia (Melastomaceæ).
Monochætum (Melastomaceæ).
Viburnum (Caprifoliaceæ).
Psammisia (Vacciniaceæ).
Cavendishia (Vacciniaceæ).
Vaccinium (Vacciniaceæ).
Sophoclesia (Vacciniaceæ).
Sphyrospermum (Vacciniaceæ).
Befaria (Ericaceæ).
Grammadenia (Myrsinaceæ).
Scaphosepalum (Orchidaceæ).
Lepanthes (Orchidaceæ).
Tofieldia (Liliaceæ).

Genera extending from the Andes along the Coast Andes of Venezuela to the Neighbourhood of Caracas, but not yet found on the Parime Mountains.

Berberis (Berberidaceæ).
Cardamine (Cruciferæ).
Arenaria (Caryophyllaceæ).
Adesmia (Leguminosæ).
Acæna (Rosaceæ).
Potentilla (Rosaceæ).
Escallonia (Saxifragaceæ).
Sedum (Crassulaceæ).
Cinchona (Rubiaceæ).
Galium (Rubiaceæ).
Espeletia (Compositæ).
Gaylussacia (Vacciniaceæ).
Muehlenbergia (Gramineæ).

Genera found on Roraima and the Mountains of South Brazil, avoiding the Chilian Andes, but occurring at low levels in Alto Amazonas, &c.

Remijia (Rubiaceæ).
Ladenbergia (Rubiaceæ).
Stifftia (Compositæ).
Hedyosmum (Chloranthaceæ).
Masdevallia (Orchidaceæ).
Stenoptera (Orchidaceæ).

of the Orchidaceæ comes first, Melastomaceæ second, Compositæ third, and Rubiaceæ and Gramineæ bracketed fourth.

It is unfortunate that all the plants collected on the upper parts of Roraima have been gathered in the last three months of the year. February brings to Roraima a few bare trees (Appun, 'Unten den Tropen,' ii. p. 226); March brings copious Gesnerads into flower, at least at the foot of the mountain (Boddam-Whetham, 'Roraima'); and April is a month producing more flowers than November (Siedel *fide* im Thurn in Trans. Linn. Soc., ser. II. ii. p. 250); but I am unable to record anything collected above 5000 feet during these months.

In conclusion, my thanks for help are due to Messrs. McConnell, Quelch, and C. B. Clarke, to my colleagues, and also to Professor T. McKenny Hughes and Dr. William Pollard.

The Flora of Roraima above 5000 *feet, as now known, with the Geographical Distribution of each Species.*

		N. Brazil.	S. Brazil, Paraguay.	Colombia to Bolivia.	Venezuela and Trinidad.	W. Indies.	Central America.	Elsewhere in America.	Old World.
MAGNOLIACEÆ.									
Drimys granatensis, Mutis	Ledge.	..	*	*	*	..	*	S.	
SARRACENIACEÆ.									
Heliamphora nutans, Benth.	to Summit.								
VIOLACEÆ.									
Sauvagesia erecta, Linn.	to Ledge.	*	*	*	*	*	*	..	*
Leitgebia Imthurniana, Oliver......	Ledge & Summit.								
POLYGALACEÆ.									
Polygala glochidiata, H. B. & K.....	to 5400 ft.	*	*	*	*	*	*		
„ *hygrophila*, H. B. & K.....	to 5400 ft.	*	*	*	*				
„ *longicaulis*, H. B. & K.	to 5400 ft.	*	*	*	*	*	*		
„ *variabilis*?, H. B. & K.....	to 5400 ft.	*	*	..	*				
Monnina cacumina, N. E. Br.	Summit.								
GUTTIFERÆ.									
Moronobea intermedia, Engl.	at 5400 ft.								
Clusia palmicida, Rich.	to 6000 ft.	*	..	..	*				
TERNSTRŒMIACEÆ.									
Marcgravia sp..................	at 5400 ft.								
Bonnetia Roraimæ, Oliver	Summit.								
Archytæa multiflora, Benth.	to 6000 ft.								
MALVACEÆ.									
Sida linifolia, Benth.	to 5400 ft.	*	*	*	*	*	*	..	Africa.
MALPIGHIACEÆ.									
Byrsonima crassifolia, H. B. & K. ..	to 5400 ft.	*	*	*	*	*	*		
Heteropteris oleæfolia, Griseb.......	to Upper slopes.								
Tetrapteris rhodopteron, Oliver	to 5400 ft.								
„ sp..................	to 5400 ft.								
RUTACEÆ.									
Ravenia ruellioides, Oliver	Upper slope.								
ILICACEÆ.									
Ilex retusa, Klotzsch	to Summit.								
„ *apicidens*, N. E. Br.	Summit.								
„ *vacciniifolia*, Klotzsch	to 6000 ft.								

		N. Brazil.	S. Brazil, Paraguay.	Colombia to Bolivia.	Venezuela and Trinidad.	W. Indies.	Central America.	Elsewhere in America.	Old World.
CYRILLACEÆ.									
Cyrilla brevifolia, N. E. Br.	Summit.								
LEGUMINOSÆ.									
Swartzia sp.	at 5000 ft.								
Cassia insignis, N. E. Br.	to Upper slopes.								
„ *polystachya*, Benth.	to Upper slopes.								
Pithecolobium ferrugineum, Benth.	to Upper slopes.								
ROSACEÆ.									
Rubus guianensis, Focke	to 7100 ft.								
„ *urticæfolius*, Poir.	to 7100 ft.	*	*	*	..	..	*		
SAXIFRAGACEÆ.									
Weinmannia guyanensis, Klotzsch	to Summit.								
„ *elliptica*, H. B. & K.	to 6000 ft.	..	..	*	..	..	*		
„ *fagaroides*, H. B. & K.	Summit.	..	..	*					
DROSERACEÆ.									
Drosera communis, St. Hil.	to Summit.	*	*	*	*	*	*		
MYRTACEÆ.									
Myrtus myricoides, H. B. & K.	to Summit.	..	..	*	*	..	*		
„ *roraimensis*, N. E. Br.	Summit.								
„ *stenophylla*, Oliver	Ledge.								
MELASTOMACEÆ.									
Microlicia bryanthoides, Oliver	to Summit.								
Cambessedesia Roraimæ, Rich. Schomb.	to 6000 ft.								
Siphanthera microlicioides, Cogn.	to 5400 ft.								
Macairea aspera, N. E. Br.	Upper slopes.								
Tibouchina fraterna, N. E. Br.	Upper slopes.								
„ *lasiophylla*, Cogn.	to 5400 ft.								
„ *aspera*, Aubl.	to 5400 ft.	*	*	*	*				
Chætolepis anisandra, Naud.	to Ledge.								
Marcetia taxifolia, DC.	to 7100 ft.	*	*						
„ *juniperina*, DC.	Summit.	..	..	*	*				
Monochætum Bonplandii, Naud.	to Summit.	..	..	*	*				
Meriania sp.	at 6000 ft.								
Centronia crassiramis, Triana	at 5750 ft.								
Miconia tinifolia, Naud.	to Summit.	..	..	..	*				
„ *holosericea*, DC.	Upper slopes.	*	*	*	*				
„ *Fothergilla*, Naud.	to 5400 ft.	*	*	*	*	*	*		
Tococa aristata, Benth.	to 6000 ft.	*	..	*					
„ *guyanensis*, Aubl.	to 6000 ft.	*	*	*	*				
„ *nitens*, Triana	to 6000 ft.	*	*	..	*				
Clidemia capitata, Benth.	to 6000 ft.	..	..	..	..	..	*		
PASSIFLORACEÆ.									
Passiflora, 2 (possibly 3) species	about 5400 ft.								
BEGONIACEÆ.									
Begonia tovarensis, Klotzsch	at 5400 ft.	..	..	*	*	*	*		
ARALIACEÆ.									
Didymopanax rugosum, N. E. Br.	Summit.								
Sciadophyllum coriaceum, March.	at 5400 ft.								
„ *umbellatum*, N. E. Br.	Upper slopes.								
Crepinella gracilis, March.	Summit.								
CAPRIFOLIACEÆ.									
Viburnum glabratum, H. B. & K.	to 7100 ft.	..	..	*	*	*	*		
RUBIACEÆ.									
Remijia Roraimæ, K. Schum.	to 6000 ft.	*							
„ *tenuiflora*, Benth.	to 6000 ft.	*							
„ *densiflora*, Benth.	to 6000 ft.								
Ladenbergia Lambertiana, Klotzsch	to 6000 ft.	*							
Chalepophyllum speciosum, N. E. Br.	Summit.								

		N. Brazil.	S. Brazil. Paraguay.	Colombia to Bolivia.	Venezuela and Trinidad.	W. Indies.	Central America.	Elsewhere in America.	Old World.
RUBIACEÆ (*cont.*).									
Sipanea pratensis, Aubl.	to 5400 ft.	*	*	*	*	*			
Coccocypselum canescens, Willd.	to 5400 ft.	*	*	*	*	. .	*		
Retiniphyllum laxiflorum, N. E. Br.	Upper slopes.								
Psychotria concinna, Oliver	to Summit.								
„ *crassa*, Benth.	to 6000 ft.	*	. .	. .	*	*			
„ *inundata*, Benth.	to 6000 ft.	*	*						
„ *Imthurniana*, Oliver	to Ledge.								
„ 2 spp.	to 6000 ft.								
Declieuxia chiococcoides, H. B. & K.	to 5400 ft.	*	*	*	*				
Cephaëlis axillaris, Sw.	to 5400 ft.	. .	. .	*	. .	*			
Relbunium sp.	to 5400 ft.								
COMPOSITÆ.									
Vernonia ehretiæfolia, Benth.	to 6000 ft.	*							
„ *remotiflora*, Rich.	to 6000 ft.	*	*						
Eupatorium conyzoides, Vahl	to 5400 ft.	*	*	*	*	*	*	N. & S.	
„ *roraimense*, N. E. Br.	Summit.								
„ *fuscum*, N. E. Br.	Summit.								
Mikania pannosa, Baker	at 5400 ft.								
Baccharis Vitis-idæa, Oliver	to Summit.								
„ sp., near *B. cassinæfolia*	Summit.								
Heterothalamus densus, N. E. Br.	Summit.								
Gnaphalium purpureum, Linn.	to 5400 ft.	*	*	*	*	*	*	N. & S.	*
Verbesina guianensis, Baker	to 5400 ft.								
Pectis elongata, H. B. & K.	to 5400 ft.	*	*	*	*	. .	*		
Quelchia conferta, N. E. Br.	Summit.								
Erechtites hieraciifolia, Rafin.	to 5400 ft.	*	*	*	*	*	*	N. & S.	Introd.
Stifftia condensata, Baker	to Summit.								
„ *Connellii*, N. E. Br.	Summit.								
LOBELIACEÆ.									
Centropogon lævigatus, A. DC.	to Ledge.	*							
„ *surinamensis*, Presl	to 5400 ft.	*	*	*	*	*	*		
VACCINIACEÆ.									
Psammisia guianensis, Klotzsch	at 6000 ft.								
„ *formosa*, Klotzsch	at 6000 ft.								
„ *coriacea*, N. E. Br.	Summit.								
„ 2 spp.	to 5400 ft.								
Notopora Schomburgkii, Hook. f.	to 5400 ft.								
Cavendishia sp. (*Thibaudia nutans*, Klotzsch)	at 6000 ft.								
Vaccinium puberulum, Klotzsch	to 6000 ft.								
„ *roraimense*, N. E. Br.	Summit.								
Sphyrospermum Roraimæ, Klotzsch	to 6000 ft. †								
Sophoclesia sp.	Ledge.								
ERICACEÆ.									
Pernettya marginata, N. E. Br.	Summit.								
Gaultheria setulosa, N. E. Br.	Summit.								
„ *cordifolia*, H. B. & K. (*G. Roraimæ*, Klotzsch)	to 5400 ft.	. .	. .	*	*	. .	*		
Ledothamnus sessiliflorus, N. E. Br.	to Summit.								
Befaria guianensis, Klotzsch	to Ledge.								
„ *Imthurnii*, N. E. Br.	Summit.								
„ *Schomburgkii*, Klotzsch	to 6000 ft.								
MYRSINACEÆ.									
Myrsine sp.	to 6000 ft.								
Cybianthus sp.	at 6000 ft.								

† If synonymous with *Hughsia guianensis*, Klotzsch & Rich. Schomb.

		N. Brazil.	S. Brazil, Paraguay.	Colombia to Bolivia.	Venezuela and Trinidad.	W. Indies.	Central America.	Elsewhere in America.	Old World.
MYRSINACEÆ (*cont.*).									
Grammadenia lineata, Benth.	to 5400 ft.								
Ardisia Quelchii, N. E. Br.	Summit.								
SAPOTACEÆ.									
Chrysophyllum emarginatum, Klotzsch †	at 6000 ft.	*							
Lucuma rigida, Mart. & Eichl.	at 5400 ft.								
APOCYNACEÆ.									
Mandevilla angustifolia (*Echites angustifolia*, Benth.)	to 6000 ft.								
,, *glabra*, N. E. Br.	Upper slopes.								
ASCLEPIADACEÆ.									
Nephradenia linearis?, Benth.	to 5400 ft.	*	..	..	*				
LOGANIACEÆ.									
Antonia ovata, Pohl	to Upper slopes.	*	*						
GENTIANACEÆ.									
Curtia tenuiflora (*Schuebleria tenuiflora*, G. Don)	to 5400 ft.	*	*	..	*	..	*		
Lisianthus uliginosus, Miq.	to Upper slopes.	*	*						
,, *Elisabethæ*, Griseb.	to Ledge.								
,, *Imthurnianus*, Oliver	Summit.								
,, *Quelchii*, N. E. Br.	Summit.								
SCROPHULARIACEÆ.									
Melasma? *spathaceum*, Oliver	Upper slopes.								
Beyrichia scutellarioides, Benth.	to Upper slopes.	*	*	..	*				
LENTIBULARIACEÆ.									
Utricularia Humboldtii, Rob. Schomb.	to Ledge.								
Utricularia nervosa?, Web.	Upper slopes.	*	*						
,, *Campbelliana*, Oliver	to Upper slopes.								
,, *alpina*, Jacq. (*U. montana*, Jacq.)	to Upper slopes.	..	..	*	..	*			
,, *Quelchii*, N. E. Br.	Summit.								
,, *roraimensis*, N. E. Br.	Summit.								
Genlisea roraimensis, N. E. Br.	Summit.								
BIGNONIACEÆ.									
Tabebuia Roraimæ, Oliver	to Upper slopes.								
VERBENACEÆ.									
Lippia Schomburgkiana, Schauer	to Upper slopes.	*							
LABIATÆ.									
Hyptis lantanæfolia, Poit.	to 5400 ft.	*	*	*	*	*	*		
POLYGONACEÆ.									
Coccoloba Schomburgkii, Meissn.	to 5400 ft.								
PIPERACEÆ.									
Peperomia reflexa, A. Dietr.	to Upper slopes.	*	*	*	*	*	*	..	*
,, *tenella*?, A. Dietr.	to Upper slopes.	..	..	..	*	*			
,, sp.	at 5400 ft.								
CHLORANTHACEÆ.									
Hedyosmum brasiliense?, Mart.	Upper slopes.	..	*						
PROTEACEÆ.									
Roupala Schomburgkii, Klotzsch	at 6000 ft.								
LORANTHACEÆ.									
Loranthus sp.	to 6000 ft.								
Phoradendron Roraimæ, Oliver	Ledge & Summit.								
EUPHORBIACEÆ.									
Phyllanthus pycnophyllus, Muell.-Arg.	at 5400 ft.								

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† Apparently *C. auratum*, Miq.

		N. Brazil.	S. Brazil, Paraguay.	Colombia to Bolivia.	Venezuela and Trinidad.	W. Indies.	Central America.	Elsewhere in America.	Old World.
EUPHORBIACEÆ (*cont.*).									
Phyllanthus sp.									
Croton lobatus, Linn.	at 6000 ft.	*	*	*	*	*	*	..	Africa.
,, sp.	Upper slopes.								
BURMANNIACEÆ.									
Burmannia bicolor, Mart.	to Upper slopes.	*	*	*	*	*	..	..	Africa.
Dictyostegia orobanchoides, Miers	to Upper slopes.	*	*	*	*				
ORCHIDACEÆ.									
Pleurothallis stenopetala, Lindl.	to Upper slopes.	..	*	..	*				
,, *roraimensis*, Rolfe	Summit.								
Stelis grandiflora, Lindl.	Upper slopes.	*							
,, *tristyla*, Lindl.	Upper slopes.	*							
Lepanthes sp.	at 5400 ft.								
Masdevallia picturata, Reichb. f.	to Upper slopes.	..	..	*	*	..	*		
Scaphosepalum breve, Rolfe	to Upper slopes.								
Octomeria parviflora, Rolfe	Summit.								
,, *Connellii*, Rolfe	Summit.								
,, sp.	Upper slope.								
Bulbophyllum sp. (*B. geraënse*, Ridley, vix Reichb. f.)	to 5400 ft.								
,, *roraimense*, Rolfe	Summit.								
Elleanthus furfuraceus, Reichb. f.	Upper slopes.	..	..	*	*				
Epidendrum elongatum, Jacq.	to Summit.	*	*	*	*	*			
,, *alsum*, Ridley	Summit.								
,, *Imthurnii*, Ridley	Summit.								
,, *tigrinum*, Lindl.	to Upper slopes.	..	..	*	*				
,, *durum*, Lindl.	to 5400 ft.	..	*						
,, *montigenum*, Ridley	Summit.								
,, *violascens*, Ridley	Summit.								
Cattleya Lawrenceana, Reichb. f.	to 6000 ft.								
Zygopetalum Burkei, Reichb. f.	to Upper slopes.								
Eriopsis Schomburgkii, Reichb. f.	to Upper slopes.	*							
Houlletia roraimensis, Rolfe	to Upper slopes.								
Catasetum discolor, Lindl.	to Upper slopes.	*	*						
Maxillaria Quelchii, Rolfe	Summit.								
Oncidium nigratum, Lindl.	to 4500 ft.								
Sobralia Liliastrum, Lindl.	to 6000 ft.	*	*						
,, sp.	Upper slope.								
Epistephium lucidum, Cogn.	to Upper slopes.	*	*						
Stenoptera viscosa, Reichb. f.	to Upper slopes.	..	..	*	*				
,, *adnata*, Ridley	Upper slopes.								
Spiranthes bifida, Ridley	to 5400 ft.								
Pogonia parviflora, Lindl.	to Upper slopes.	..	*	..	..	..	..	S.	
,, *rosea*, Hemsl.	to Upper slopes.	*	..	*	*				
,, *tenuis*, Reichb. f.	Summit.	*	..	*	*				
Habenaria roraimensis, Rolfe	Summit.								
,, *parviflora*, Lindl.	to 5400 ft.	*	*	*	*	..	..	S.	
,, *Moritzii*, Ridley	to Upper slopes.	..	..	..	*				
Selenipedium Lindleyanum, Reichb. f.	to 5400 ft.								
BROMELIACEÆ.									
Brocchinia cordylinoides, Baker	to Ledge.								
Puya floccosa, Morren	at 6000 ft.	..	..	*	*				
Connellia Augustæ, N. E. Br.	to Summit.								
,, *Quelchii*, N. E. Br.	Summit.								
Tillandsia rhodocincta, Baker	Summit.								

		N. Brazil.	S. Brazil, Paraguay.	Colombia to Bolivia.	Venezuela and Trinidad.	W. Indies.	Central America.	Elsewhere in America.	Old World.
LILIACEÆ.									
Nietneria corymbosa, Klotzsch & Rich. Schomb.	to Summit.								
Tofieldia Schomburgkiana, Oliver	to Summit.								
XYRIDACEÆ.									
Xyris setigera, Oliver	to Ledge.	..	*						
,, *Seubertii*, Nills.†	Upper slopes (? Ledge).								
,, *witserioides*, Oliver	to 7300 ft.								
,, *concinna*, N. E. Br.	Summit.								
Abolboda Sceptrum, Oliver	to Summit.								
RAPATEACEÆ.									
Saxofredericia regalis, Rob. Schomb.	to 5600 ft.								
Stegolepis guianensis, Klotzsch	to Summit.								
PALMÆ.									
Euterpe sp.	at 5400 ft.								
Geonoma Appuniana, Spruce	to Upper slopes.								
ARACEÆ.									
Anthurium roraimense, N. E. Br.	at 5400 ft.								
ERIOCAULACEÆ.									
Pæpalanthus Schomburgkii, Klotzsch	to 5400 ft.								
,, *flavescens*, Koern.	to Upper slopes.	*	*	*	*				
,, *Roraimæ*, Oliver	to Summit.								
,, *fraternus*, N. E. Br.	Summit.								
CYPERACEÆ.									
Fimbristylis exilis, Roem. & Schult.	to 5400 ft.	*	..	..	*	*	*	..	Africa.
Rhynchospora stenophylla, Britton ‡.	at 5400 ft.	..	..	..	..	*	..	N.	
,, *tenuis*, Britton	to 5400 ft.	*	*	..	..	*	*	S.	
Lagenocarpus stellatus, C. B. Clarke (*Cryptangium stellatum*, Boeckl.)	Upper slopes.								
Everardia montana, Ridley	to Summit.								
,, *angusta*, N. E. Br.	Summit.								
Scleria hirtella, Sw.	to 5400 ft.	*	*	*	*	*	*	N.	Africa.
,, *bracteata*, Cav.	to 5400 ft.	*	*	*	*	..	*	..	*
GRAMINEÆ.									
Saccharum cayennense, Beauv.	to 5400 ft.	*	*	*	*	*	*	S.	
Ischæmum latifolium, Kunth	to 5400 ft.	*	*	*	*	*	*		
Arundinella brasiliensis, Raddi	to 5400 ft.	*	*	*	*	*	*	S.	*
Paspalum stellatum, Fluegge	to 5400 ft.	*	*	*	*				
Panicum eligulatum, N. E. Br.	Summit.								
,, *nervosum* ?, Lam.	to 5400 ft.	*	..	..	*				
Echinolæna hirta, Desv.	to Upper slopes.	*	*						
Arundo roraimensis, N. E. Br.	Summit.								
Arundinaria deflexa, N. E. Br.	Summit.								
Chusquea linearis, N. E. Br.	Summit.								
Guadua sp.	to Upper slopes.								
Total of SPERMATOPHYTA	....	67	55	53	60	30	33	11	10

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† *X. Fontanesiana*, Oliver in Trans. Linn. Soc., ser. II. Bot. ii. (1887), p. 285, appears to be *X. Seubertii*. It is not *X. Fontanesiana*, Kunth.

‡ *R. capillacea*, Oliver *l. c.* p. 287, not of Torrey (*teste* C. B. Clarke).

		N. Brazil.	S. Brazil, Paraguay.	Colombia to Bolivia.	Venezuela and Trinidad.	W. Indies.	Central America.	Elsewhere in America.	Old World.
SELAGINELLACEÆ.									
Selaginella vernicosa, Baker	to Summit.								
,, *roraimensis*, Baker	at 5400 ft.	*							
LYCOPODIACEÆ.									
Lycopodium alopecuroides, Linn.....	to Upper slopes.	*	*	*	*	..	..	N. & S.	
,, *carolinianum*, Linn. ..	to Upper slopes.	*	*	*	*	*	..	N.	*
,, *contiguum*, Klotzsch ..	to Summit.	..	..	*	*				
,, *linifolium*, Linn.......	to Upper slopes.	*	*	*	*	*	*		
,, *subulatum*, Desv.	to 7200 ft.	..	*	*	*	..	*	..	Pacific.
FILICES.									
Gleichenia pubescens, H. B. & K. ..	to Upper slopes.	*	*	*	*	*	*	S.	
Cyathea vestita, Mart.............	to 5400 ft.	*	*						
Alsophila bipinnatifida, Baker	5400 ft.	*	..	*					
,, *macrosora*, Baker	at 5400 ft.								
Dicksonia coniifolia, Hook.........	to Summit.	*	*	*	*	*			
Hymenophyllum crispum, H. B. & K.	to Summit.	*	..	*	*	*	*		
,, *dejectum*, Baker ..	5000 ft. to Summit.								
,, *polyanthos*, Sw. ..	to Summit.	*	*	*	*	*	*	S.	*
,, *fucoides*, Sw.	to Upper slopes.	..	*	*	*	*	*	S.	
,, *microcarpum*, Hook.	Upper slopes.	*	*	*	*	*	*		
,, *sericeum*, Sw.	to Summit.	*	*	*	*	*	*		
,, *lineare*, Sw.	to Summit.	*	*	*	*	*	*	..	Africa.
Trichomanes elegans, Rudge	to Upper slopes.	*	..	*	*	..	*		
,, *roraimense*, Jenman ..	Summit.								
,, *macilentum*, V. d. Bosch	to Upper slopes.	*	*	*	*				
,, *rigidum*, Sw.	to 5400 ft.	*	*	*	*	*	*	..	*
,, *pyxidiferum*, Linn. ..	to Upper slopes.	*	*	*	*	*	*	..	*
Davallia Imrayana, Hook.	to Upper slopes.	..	..	..	..	*	*		
Lindsaya guianensis, Dryand.......	to Upper slopes.	*	*	*	*	*	*		
,, *stricta*, Dryand.	to Summit.	*	*	*	*	*	*		
Hypolepis repens, Presl	to 7200 ft.	*	*	*	*	*	*		
Pteris aquilina, Linn.............	to Summit.	*	*	*	*	*	*	N. & S.	*
,, *incisa*, Thunb.	to 7200 ft.	*	*	*	*	*	*	S.	*
,, *lomariacea*, Kunze	to 5400 ft.	*	*	*					
Lomaria Plumieri, Desv............	to Upper slopes.	*	*	*	*	*			
,, *Boryana*, Willd.	to Summit.	*	*	*	*	*	..	S.	Africa.
,, *procera*, Spreng.	to Summit.	*	*	*	*	*	*	S.	*
Asplenium lunulatum, Sw.	to 7200 ft.	*	*	*	*	*	*	S.	*
,, *rhizophorum*, Kunze	to Upper slopes.	*	*	*	*	*	*	..	Pacific.
,, *furcatum*, Thunb.	to 5400 ft.	*	*	*	*	*	*	..	*
,, *serra*, Langsd. & Fisch...	Summit.	*	*	*	*	*	*	..	Africa.
Nephrodium conterminum, Desv.....	to Summit.	*	*	*	*	*	*	N. & S.	
,, *denticulatum*, Hook. ..	to Summit.	*	*	*	*	*	*		
,, *brachypodum*, Baker ..	Upper slopes.								
,, *Leprieurii*, Hook.	to 5400 ft.	*	..	*					
,, *amplissimum*, Hook. ..	to Upper slopes.	*	*						
Nephrolepis cordifolia, Presl	to 5400 ft.	*	*	*	*	*	*	..	*
Polypodium marginellum, Sw.	to Summit.	*	..	*	*	*	*	..	*
,, *Connellii*, Baker	Summit.								
,, *demeraranum*, Baker ..	Upper slopes.								
,, *roraimense*, Baker	Upper slopes.								
,, *trifurcatum*, Linn.	to Upper slopes.	..	..	*	..	*			
,, *furcatum*, Mett.	to Summit.	*	..	..	..	*			
,, *serrulatum*, Mett.	to Summit.	*	*	*	*	*	*	..	*
,, *tovarense*, Klotzsch	Upper slopes.	..	..	*	*				
,, *truncicola*, Klotzsch....	Upper slopes.	..	..	*	*	*	*		
,, *moniliforme*, Lag. ...	to Summit.	..	..	*	*	*	*		
,, *leptopodon*, C.H. Wright	Summit.								
,, *trichomanoides*, Sw.....	to Upper slopes.	*	*	*	*	*	*	Juan F.	*
,, *taxifolium*, Linn.......	to Upper slopes.	*	*	*	*	*	*		
,, *pectinatum*, Linn.	to 5400 ft.	*	*	*	*	*		N.	
,, *cultratum*, Willd.	to Upper slopes.	*	*	*	*	*	*	..	Africa.

		N. Brazil.	S. Brazil, Paraguay.	Colombia to Bolivia.	Venezuela and Trinidad.	W. Indies.	Central America.	Elsewhere in America.	Old World.
FILICES (*cont.*).									
Polypodium xanthotrichum, Klotzsch	Upper slopes.								
,, *capillare*, Desv.	to Upper slopes.	*	..	*	*	*			
,, *Kalbreyeri*, Baker	Upper slopes.	..	..	*					
,, *rigescens*, Bory	to Summit.	*	*	*	*	*	..	..	*
,, *firmum*, Klotzsch	Upper slopes.	..	..	*	*	*			
,, *meridense*, Klotzsch	Summit.	..	*	*	*				
,, *subsessile*, Baker	Upper slopes.	..	..	*					
,, *melanotrichum*, Baker	at 5400 ft.								
,, *loriceum*, Linn.	to 7200 ft.	*	*	*	*	*	*	S.	
,, *aureum*, Linn.	to 5400 ft.	*	*	*	*	*	*	N.	Australia.
,, *angustifolium*, Sw.	to 5400 ft.	*	*	*	*	*	*		
Gymnogramme elaphoglossoides, Baker	to Summit.								
,, *cyclophylla*, Baker	Summit.								
,, *flexuosa*, Desv.	to Summit.	*	*	*	*	..	*		
,, *Schomburgkiana*, Kunze	Upper slopes.								
,, *hirta*, Desv.	Upper slopes.	..	..	*	*	..	*		
Enterosora Campbellianum, Baker	Summit.								
Vittaria lineata, Sw.	to Upper slopes.	*	*	*	*	*	*	N. & S.	*
,, *stipulata*, Kunze	Upper slopes.	..	..	*	*	*			
Acrostichum latifolium, Sw.	to Summit.	*	*	*	*	*	*	..	*
,, *squamosum*, Sw.	to Upper slopes.	*	*	*	*	*	*	..	*
,, *leptophlebium*, Baker	Upper slopes.								
,, *muscosum*, Sw.	to 5400 ft.	*	*	*	..	*			
,, *stenopteris*, Klotzsch	at 5400 ft.	..	..	*	*	*			
,, *decoratum*, Kunze	to 5400 ft.	..	*	*	..	*			
,, *peltatum*, Sw.	to Upper slopes.	*	..	*	*	*	*		
Schizæa dichotoma, Sw.	to 5400 ft.	..	..	*	*	*	..	..	*
,, *elegans*, Sw.	to 5400 ft.	*	*	*	*	*	*		
Aneimia tomentosa, Sw.	to 5400 ft.	*	*	*	*	*	*	S.	
Total of PTERIDOPHYTA	....	55	50	67	59	55	45	17	25
BRYINEÆ.									
Dicranum longisetum, Hook.	Ledge.	..	..	*	*				
Dicranodontium pulchroalare, Broth.	Ledge.								
Campylopus chionophyllus, Mitt.	Ledge.	..	..	*					
,, *Roraimæ*, Broth.	Ledge.								
,, *atratus*, Broth.	Summit.								
Leucobryum megalophyllum, Mitt.	Ledge.	..	*	*	*	*	..	*	
,, *lævifolium*, Broth.	Summit.								
Octoblepharum Mittenii, Jaeg.	Summit.	*	*	..	*				
Leptodontium cirrhifolium, Mitt.	Summit.	..	..	*					
Zygodon subdenticulatus, Hampe	Summit.	..	..	*					
Funaria calvescens, Schwaeg.	Ledge.	*	*	*	*	*	*	N. & S.	*
Breutelia scoparia, Besch.	Summit.	..	..	..	..	*			
Rhizogonium Lindigii, Mitt.	Summit.	..	..	*	..	..	*		
Mnium rostratum, Schrad.	to Ledge.	*	*	*	*	*	*	*	*
Polytrichum aristiflorum, Mitt.	to 5400 ft.	..	*	*	*	*	*		
Rhacocarpus Humboldtii, Lindb.	Summit.	..	*	*	..	*	..	S.	*
Hookeria pilotrichelloides, Broth.	Ledge.								
,, *crispa*, C. Muell.	to 5400 ft.	..	*	*	*	..	*		
Ectropothecium amabile, Mitt.	to Summit.	..	..	*					
Ctenidium malacodes, Mitt.	Ledge.	..	..	*					
Thuidium pseudoprotensum, Mitt.	Ledge.	..	..	..	*				
Hypopterygium tamarisci, Brid.	to 5400 ft.	*	*	*	*	*	*	S.	*
SPHAGNACEÆ.									
Sphagnum sanguinale, Warnst.	Ledge.								
,, *medium*, Limpr.	Ledge.	..	*	..	..	..	..	N. & S.	*
MARCHANTIACEÆ.									
Dumortiera hirsuta, Nees	Ledge.	..	*	..	..	*	*	..	*

		N. Brazil.	S. Brazil, Paraguay.	Colombia to Bolivia.	Venezuela and Trinidad.	W. Indies.	Central America.	Elsewhere in America.	Old World.
JUNGERMANNIACEÆ.									
Aneura Schwaneckei, Steph.	Summit.	..	*	..	..	*			
,, *algoides*, Steph.	Summit.	..	..	*					
,, *roraimensis*, Steph.	Summit.								
,, *Breutelii*, Steph.	Summit.	..	..	..	..	*			
,, *fucoides*, Steph. (*A. bipinnata*, Mitt.†)	Ledge.	..	*	..	..	*	*		
Metzgeria inflata, Steph.	Summit.								
,, *hamata*, Lindb.	Ledge.	..	..	*	..	*	*	N. & S.	*
Pallavicinius Wallisii, Jack & Steph.	Summit.	..	..	*					
Jamesoniella colorata, Spruce	Summit.	..	..	*	..	..	*	S.	*
Syzygiella Quelchii, Steph.	Ledge.								
,, *perfoliata*, Spruce	Summit.	..	..	..	*	*			
Plagiochila ærea, Tayl.	Ledge.	..	..	..	*	..	*		
,, *gavana*, Steph.	Ledge.								
,, *remotifolia*, Hampe & Gottsche	Ledge.	..	..	..	..	*			
,, *rutilans*, Lindb.	Ledge.	*	*	*	*	*	*		
,, *adiantoides*, Lindb.	to Upper slopes.	..	*	*	..	*	*		
Leioscyphus fragilis, Jack & Steph.	Summit.	..	..	*					
Lophocolea Breutelii, Gottsche	Ledge.	..	..	..	..	*			
Mastigobryum roraimense, Steph.	Summit.								
,, *dissodontum*, Spruce	Summit.	..	..	*					
,, *vincentinum*, Lehm. & Lindenb.	Ledge.	..	..	..	..	*			
,, *Krugianum*, Steph.	Ledge.	..	..	..	..	*			
,, *gracile*, Hampe & Gottsche	Ledge.	..	..	..	..	*			
Blepharozia Roraimæ, Mitt.	Summit.								
Micropterygium grandistipulum, Steph.	Ledge.								
,, *pterygophyllum*, Spruce	Summit.	*	*	*	..	*			
Lepidozia commutata, Steph.	Summit.	..	..	..	..	*			
Schisma juniperinum, Nees	Summit.	..	*	*	..	*	*	N. & S.	*
,, *pensilis*, Steph.	Ledge.	..	..	*					
,, *Durandii*, Steph.	Ledge.	..	..	..	..	..	*		
,, *subedentatum*, Steph.	Ledge.								
Trichocolea sphagnoides, Steph.	Ledge.	..	..	*					
Scapania portoricensis, Hampe & Gottsche	Summit.	..	..	*	..	*			
Pleurozia paradoxia, Jack	Summit.	..	..	*					
Harpalejeunea tenax, Steph.	Ledge.								
Frullanea mirabilis, Jack & Steph.	Summit.	..	..	*					
,, *atrata*, Nees	Summit.	*	*	*	*	*	*		
,, *longicollis*, Lindenb. & Gottsche	Summit.	..	..	*	..	..	*		
Total of BRYOPHYTA	....	7	17	31	13	25	17	8	9
Phoma Psammisiæ, Massee	Summit.								
Echinobotryum roseum, Massee	Summit.	..	..	..	..	..	..	..	*
Stenophylium ericoctonum, R. Br.	Summit.								
Macrosporium ramulosum, Sacc.	Summit.	..	..	*	..	..	..	..	*
Capnodium fibrosum, Berk.	Summit.	..	..	..	..	..	..	..	*
Rhipidonema membranaceum, Sacc.	Ledge.	*	..	..	..	..	..	..	Pacific.
Sphærophora compressum, Achar.	Summit.	..	..	..	..	*	..	S.	*
Cladonia rangiferina, Hoffm.	Summit.	*	*	*	*	*	*	N. & S.	*
Parmelia dictyorhiza, Massee	Summit.								
,, *perforata*, Achar.	Summit.	..	..	..	..	..	*	N.	Pacific.
Alectoria ochroleuca, Nyl.	Summit.	..	..	..	..	..	*	N.	*
Total of THALLOPHYTA	....	2	1	2	1	2	3	4	8

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† In Trans. Linn. Soc., Bot. ser. II. ii. p. 296.

CHIEF LITERATURE.

Schomburgks' journeys.

Sir Robert H. Schomburgk, in Proc. Roy. Geogr. Soc. x. 1840, pp. 196–242.

Sir Robert H. Schomburgk, 'Twelve Views in the Interior of Guiana' (London, 1841).

Sir Richard Schomburgk, 'Reisen in Britisch-Guiana' (Leipzig, 1847–48), ii. pp. 152–300; iii. pp. 1041–1104.

Sir Richard Schomburgk, 'Botanical Reminiscences of British Guiana' (Adelaide, 1876).

Sir Robert H. Schomburgk, in Verh. Gartenb. Ver. xv., 1841.

G. Bentham, in Ann. Nat. Hist. ii.–iii.; in Hooker's Journ. Bot. ii.–iv.; in Hooker's Lond. Journ. Bot. i.–vii.; in Trans. Linn. Soc. xviii. & xxii.; &c.

J. F. Klotzsch, in Verh. Gartenb. Ver. xviii., 1847; in 'Linnæa,' xxiv. 1851, p. 1; &c.

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Brown and Sawkins's journey.

C. B. Brown, 'Canoe and Camp-life, in Guiana.' 2nd edit. (London, 1877), pp. 118–124.

J. G. Sawkins, in Proc. Roy. Geogr. Soc. xv. 1870–71, p. 131.

C. B. Brown and J. G. Sawkins, 'Report on the Physical, Descriptive and Economic Geology of British Guiana' (London, 1875), pp 61–63.

Boddam-Whetham and McTurk's journey.

J. W. Boddam-Whetham, 'Roraima and British Guiana' (London, 1879), pp. 204–254.

im Thurn and Perkins's journey.

E. F. im Thurn, in Proc. Roy. Geogr. Soc. vii. 1885, pp. 497–521, and in 'Timehri,' iv. 1885, pp. 1–48 and 256–267.

H. I. Perkins, in Proc. Roy. Geogr. Soc. vii. 1885, pp. 529–530.

E. F. im Thurn, D. Oliver, and others in Trans. Linn. Soc. Ser. II. Bot. ii. pp. 249–300; reprinted in 'Timehri,' v. 1886, pp. 145–223.

Kromer's and Dressel's journeys.

'Timehri,' n. s., i. 1887, p. 330.

McConnell and Quelch's first journey.

J. J. Quelch in 'Timehri,' n. s., viii. 1894, p. 381; ix. 1895, pp. 107–188.

ENUMERATION OF THE PLANTS COLLECTED.

I. SPERMATOPHYTA.

By N. E. BROWN, A.L.S. (the Orchids by R. A. ROLFE, A.L.S.).

SARRACENIACEÆ.

HELIAMPHORA NUTANS, Benth. in Proc. Linn. Soc. i. (1840), p. 53, and in Trans. Linn. Soc. xviii. (1840), p. 429, t. 29; R. Schomb. Reisen in Brit.-Guiana, ii. p. 263, and iii. p. 1090; R. H. Schomb., Views in the Interior of Guiana, p. 15; Bot. Mag. t. 7093; Fl. des Serres, Sér. II. xi. (1875), p. 149, tt. 2246-47; Oliver, in Trans. Linn. Soc. Ser. II. Bot. ii. (1887), p. 271.

Summit of Mount Roraima, *McConnell & Quelch*, 78, 679; also collected on the lower slope in the "Eldorado Swamp" by all other collectors.—Endemic.

VIOLACEÆ.

IONIDIUM IPECACUANHA, Vent. Jard. Malm. sub t. 27.
Ireng Valley, *McConnell & Quelch*, 258.

ALSODEIA FLAVESCENS, Spreng. Syst. i. p. 806.
Mazaruni River, 300 ft., *McConnell & Quelch*, 715.

SAUVAGESIA ERECTA, Linn. Sp. Pl. ed. i. p. 203; Oliver, in Trans. Linn. Soc. Ser. II. Bot. ii. (1887), p. 271.

Upper slopes and ledge of Mount Roraima, *McConnell & Quelch*, 7. Ireng Valley, *McConnell & Quelch*, 263.—Widely distributed in Tropical America.

SAUVAGESIA SPRENGELII, A. St. Hil. in Mém. Mus. Par. xi. (1824), p. 97.
Savannahs generally, *McConnell & Quelch*, 330.

LEITGEBIA IMTHURNIANA, Oliver, in Trans. Linn. Soc. Ser. II. Bot. ii. (1887), p. 271, t. 37A.
Summit of Mount Roraima, *McConnell & Quelch*, 97, 98, 316, 654.—Endemic.

POLYGALACEÆ.

POLYGALA GLOCHIDIATA, H. B. & K. Nov. Gen. & Sp. v. p. 400.

Upper slopes of Mount Roraima, *McConnell & Quelch*, 38.—Widely distributed in Tropical America.

POLYGALA HYGROPHILA, H. B. & K. Nov. Gen. & Sp. v. p. 395; Oliver, in Trans. Linn. Soc. Ser. II. Bot. ii. (1887), p. 271.

Upper slopes of Mount Roraima, *McConnell & Quelch*, 39.—Eastern Tropical America from Panama to Paraguay.

Polygala Timoutou, Aubl. Pl. Guian. ii. p. 737, t. 295; R. Schomb. Reisen in Brit.-Guiana, iii. p. 1097.

Kotinga Valley, *McConnell & Quelch*, 196. Ireng Valley, *McConnell & Quelch*, 250.

Polygala celosioides, Mart. *ex* A. W. Benn. in Mart. Fl. Bras. xiii. pt. iii. p. 35.

Ireng Valley, *McConnell & Quelch*, 223.

Securidaca marginata, Benth. in Hook. Journ. Bot. iv. (1842), p. 103.

Kotinga Valley, *McConnell & Quelch*, 157.

Monnina cacumina, N. E. Brown, sp. n. Folia oblonga, acuta vel obtusa, apiculata, exstipulata, glabra. Racemi densiflori, floribus breviter pedicellatis. Bracteæ lanceolatæ, acutæ, floribus breviores. Alæ ellipticæ, glabræ, basi ciliatæ. Carina glabra, ciliata. Petala lateralia utrinque pubescentia. Vagina staminea supra hirta. Fructus compresso-ellipsoideus, exalatus, uniloculàris, glaber.

Stem subglabrous, or very thinly covered with very short hairs. Leaves about 2 in. long, ⅔–1 in. broad, oblong or oblong-lanceolate, acute or obtuse and apiculate, rather thin in the dried state, exstipulate. Racemes 3–4, terminal, 2–4 in. long, rather densely many-flowered. Bracts 2 lin. long, ⅔ lin. broad, lanceolate, acute, caducous. Pedicels ½–1 lin. long. Dorsal sepal 1⅓ lin. long, ⅔ lin. broad, ovate, acute, concave, ciliolate; the two lower sepals similar but rather smaller, connate to their middle; lateral sepals or alæ about 2¼ lin. long, 2 lin. broad, elliptic, obtuse, with incurved margins, glabrous, ciliate towards the base. Lower petal or keel 2½ lin. long, 2 lin. broad, obscurely 3-crenulate at the apex, glabrous ciliate along the sides. Lateral petals 2–2½ lin. long, obliquely tapering from a broad base to an obtuse apex, adnate to the staminal tube, densely ciliate along the upper margin, pubescent along the middle of the outer side and more densely all over within. Staminal tube villose at the apex. Ovary elliptic, with a large unilateral gland at its base, glabrous; style thickened upwards, slightly incurved. Fruit 3–3½ lin. long, about 1¾ lin. broad, elliptic, subacute, compressed, not winged, 1-celled, glabrous.

Summit of Mount Roraima, 8600 ft. *McConnell & Quelch*, 645.

Allied to *M. cestrifolia*, H. B. & K., but differing in its much larger flowers.

Krameria spartioides, Klotzsch, *ex* O. Berg, in Bot. Zeit. xiv. (1856), p. 761.

Ireng Valley, *McConnell & Quelch*, 244, 268.

VOCHYSIACEÆ.

Trigonia subcymosa, Benth. in Hook. Lond. Journ. Bot. ii. (1843), p. 373.

Ireng Valley, *McConnell & Quelch*, 222.

PORTULACACEÆ.

Portulaca sedifolia, N. E. Brown, sp. n. Caules humiles, diffusi. Folia parva, lineari-oblonga vel oblongo-lanceolata, breviter petiolata, axillis dense pilosa. Calycis lobi late ovati, obtusi, apice inflexi, glabri. Petala calyce duplo longiora. Stamina 5. Stylus 3-fidus. Semina tuberculata.

A small succulent herb, branching at the base, with branches 2–3 in. long, glabrous, with the exception of the tufts of long white hairs in the axils of the leaves and around the flowers. Leaves 1½–3 lin. long, ½–⅔ lin. broad, flattened, linear-oblong or oblong-lanceolate, obtuse, tapering at the base into a short petiole, glabrous. Flowers small. Sepals ¾ lin. long, rather more than ½ lin. broad, broadly ovate, obtuse, inflexed at the apex, concave, not keeled on the back, glabrous. Petals 1½ lin. long, only seen in a withered state, apparently obtuse. Stamens 5, shorter than the petals. Style filiform, with 3 filiform stigmas. Upper half of the capsule broadly conical. Seeds ¼ lin. diam., tuberculate, the tubercles on the sides very much larger than those on the back, black.

Ireng Valley, *McConnell & Quelch*, 237.

Allied to *Portulaca parvula*, A. Gray, but differing in its shorter leaves, fewer stamens, and larger and more coarsely tuberculate seeds.

GUTTIFERÆ.

Clusia Planchoniana, Engl. (?) in Mart. Fl. Bras. xii. pt. I. p. 431.

Kukenaam River, *McConnell & Quelch*, 130.

I am doubtful of my identification of this plant, and it may prove to be a new species, but the specimen only consists of three flowers and two leaves, all detached. They agree fairly well with the flowers and leaves of *C. Planchoniana*, with the exception that the leaves are rather more obtuse and have stouter petioles.

TERNSTRŒMIACEÆ.

Ternstrœmia Schomburgkiana, Benth. in Hook. Lond. Journ. Bot. ii. (1843), p. 362; Appun, Unter den Tropen, ii. p. 292.

Kotinga Valley, *McConnell & Quelch*, 138.

Bonnetia sessilis, Benth. in Hook. Lond. Journ. Bot. ii. (1843), p. 363; Appun, Unter den Tropen, ii. p. 292; R. Schomb. Reisen in Brit.-Guiana, ii. pp. 218, 251, and iii. p. 1093.

Irengwatong Creek in the Ireng Valley, *McConnell & Quelch*, 269, 322.—Only known from this western part of British Guiana.

Bonnetia Roraimæ, Oliver, in Trans. Linn. Soc. Ser. II. Bot. ii. (1887), p. 272, t. 37. f. B.

Summit of Mount Roraima, *McConnell & Quelch*, 84, 664.—Endemic. According to Mr. Quelch, "this is the commonest and most widely spread species on the summit, rising to 35–40 ft. in height, where sheltered."

Archytæa multiflora, Benth. in Hook. Lond. Journ. Bot. ii. (1843), p. 363; R. Schomb. Reisen in Brit.-Guiana, ii. p. 218, and iii. p. 1093.

Kotinga Valley, 3000 ft. *McConnell & Quelch*, 162; Ireng Valley, *McConnell & Quelch*, 311.

MAHURIA EXSTIPULATA, Benth. in Hook. Lond. Journ. Bot. ii. (1843), p. 365.
Silima Creek in the Ireng Valley, *McConnell & Quelch*, 270.

MALVACEÆ.

SIDA, sp. Specimen insufficient for determination, but apparently a new species.
Ireng Valley, *McConnell & Quelch*, 267.

PAVONIA SPECIOSA, H. B. & K. Nov. Gen. & Sp. v. p. 281.
Kotinga Valley, *McConnell & Quelch*, 176. Karona Falls on the Ireng River, *McConnell & Quelch*, 228. Ireng Valley, *McConnell & Quelch*, 257.

PAVONIA CANCELLATA, Cav. Diss. iii. p. 135.
Ireng Valley, *McConnell & Quelch*, 248.

FUGOSIA CAMPESTRIS, Benth. in Hook. Journ. Bot. iv. (1842), p. 120.
Ireng Valley, *McConnell & Quelch*, 213, 239.

STERCULIACEÆ.

HELICTERES GUAZUMÆFOLIA, H. B. & K. Nov. Gen. & Sp. v. p. 304.
Ireng Valley, *McConnell & Quelch*, 212.

MELOCHIA MELISSÆFOLIA, Benth. in Hook. Journ. Bot. iv. (1842), p. 129.
Ireng Valley, *McConnell & Quelch*, 231.

MELOCHIA HIRSUTA, Cav. Diss. vi. p. 323.
Ireng Valley, *McConnell & Quelch*, 255.

WALTHERIA VISCOSISSIMA, A. St. Hil. Fl. Bras. Mer. i. p. 150.
Kotinga Valley, *McConnell & Quelch*, 168.

MALPIGHIACEÆ.

BYRSONIMA VERBASCIFOLIA, Rich. *ex* Juss. in Ann. Mus. Par. xviii. (1811), p. 481.
Ireng Valley, *McConnell & Quelch*, 226.

HETEROPTERIS OLEÆFOLIA, Griseb. in Linnæa, xxii. (1849), p. 19.
H. daphnoides, Griseb. in R. Schomb. Reisen in Brit.-Guiana, iii. p. 1096.
Upper slopes of Mount Roraima, *McConnell & Quelch*, 21, 319.—Endemic.

TETRAPTERIS SQUARROSA, Griseb. in Mart. Fl. Bras. xii. pt. I. p. 87.
Ireng Valley, *McConnell & Quelch*, 241.

GERANIACEÆ.

OXALIS DISTANS, A. St. Hil. Fl. Bras. Mer. i. p. 115.
O. Schomburgkiana, Prog. in Mart. Fl. Bras. xii. pt. II. p. 500.
Ireng Valley, *McConnell & Quelch*, 202.

OCHNACEÆ.

Pœcilandra retusa, Tul. in Ann. Sc. Nat. Sér. III. viii. (1847), p. 342.

Kotinga Valley, *McConnell & Quelch*, 145, 167. Ireng Valley, *McConnell & Quelch*, 325.

ILICACEÆ.

Ilex apicidens, N. E. Brown, sp. n. (Plate 1, figs. 1–6). Frutex glaber. Folia parva, coriacea, elliptica, obtusa vel emarginata, basi obtusa, apice denticulata. Cymæ axillares vel ad apices ramulorum aggregatæ, 2–3-floræ, vel flores solitarii, glabræ. Calyx 4-lobus, lobis brevissimis rotundatis. Petala 4, elliptica vel suborbiculata, obtusissima. Stamina 4.

A glabrous shrub; branches tuberculated with the scars of the fallen leaves. Leaves moderately crowded, coriaceous; petiole $\frac{1}{2}$–2 lin. long; blade 5–11 lin. long, 4–7 lin. broad, elliptic or somewhat obovate, obtusely rounded or emarginate and with 5–9 small teeth at the apex, obtusely rounded or somewhat cuneate at the base, entire along the sides, with slightly revolute margins, not punctate-dotted beneath; primary lateral veins about 4 on each side, uniting in broad loops, impressed above, prominent beneath; stipules minute, about $\frac{1}{3}$ lin. long, subulate. Flowers either solitary or in 2–3-flowered pedunculate cymes in the axils of the leaves, or crowded into a small, terminal, hemispherical corymb $\frac{1}{2}$–$\frac{3}{4}$ in. diam. Peduncles $1\frac{1}{2}$–3 lin. long, glabrous. Pedicels of the solitary flowers 2–$3\frac{1}{2}$ lin. long, of those in cymes 1–$2\frac{1}{2}$ lin. long, glabrous. Calyx about $\frac{1}{2}$ lin. long, cupular, shortly 4-lobed, lobes broadly rounded, obtuse, glabrous. Petals 4, $1\frac{1}{4}$–$1\frac{1}{2}$ lin. long, $1\frac{1}{4}$–$1\frac{1}{3}$ lin. broad, elliptic or suborbiculate, very obtuse, concave, glabrous. Stamens 4, a little shorter than the petals. Pistillode globose, glabrous. Female flowers not seen.

Summit of Mount Roraima, 8600 ft., *McConnell & Quelch*, 634.

Allied to *I. obcordata*, Sw., but differing in the apically toothed leaves, with the midrib and veins much more prominent beneath.

Ilex retusa, Klotzsch, in R. Schomb. Reisen in Brit.-Guiana, iii. p. 1097; Oliver, in Trans. Linn. Soc. Ser. II. Bot. ii. (1887), p. 273.

Summit of Mount Roraima, *McConnell & Quelch*, 655. Collected by Schomburgk on the bank of a mountain-stream in the vicinity of Roraima.—Endemic.

CYRILLACEÆ.

Cyrilla antillana, Michx. Fl. Bor.-Am. i. p. 158.

Stachyanthemum Schomburgkii, Klotzsch, in R. Schomb. Reisen in Brit.-Guiana, iii. p. 1097, *ex* Loesener, in Engler & Prantl, Pflanzenfam. iii. pt. 5, p. 459.

Kotinga Valley, 3000 ft., *McConnell & Quelch*, 193. Ireng Valley, *McConnell & Quelch*, 203.

Cyrilla brevifolia, N. E. Brown, sp. n. (Pl. 1, figs. 7–16.) Folia lanceolato-elliptica vel obovato-elliptica vel lanceolata, obtusa vel acuta, glabra, rigide coriacea, costa infra vix prominente. Racemi 1–2 poll. longi, dense multiflori. Sepala lanceolata, acuminata, glabra. Petala lanceolata, involuto-acuminata, glabra.—*C. antillana*, Michx., var. *brevifolia*, Oliver, in Trans. Linn. Soc. Ser. II. Bot. ii. (1887) p. 273.

Leaves crowded towards the ends of the branches, glabrous; petiole 2–2½ lin. long; blade ¾–1¼ in. long, 4–8 lin. broad, lanceolate-elliptic or slightly obovate-elliptic and obtuse, or occasionally lanceolate and acute, sometimes minutely apiculate, rigidly coriaceous, entire, shining and smooth or coarsely pitted above, coarsely pitted between the veinlets beneath; midrib impressed above, prominent and keeled beneath at the basal part only, not raised above the general surface in the apical half. Racemes 1–2 in. long, 3–4 lin. diam., densely many-flowered, erect, glabrous. Bracts 1½–2 lin. long, subulate, very acute. Pedicels ¾–1 lin. long, ascending curved, glabrous. Sepals 1–1¼ lin. long, acuminate from an ovate base, glabrous. Petals 1½–1¾ lin. long, ½ lin. broad, lanceolate, acuminate from the margins being inrolled, subacute when expanded, glabrous. Stamens about ⅔ as long as the petals. Ovary oblong, irregularly wrinkled in the dried state, 2–3-celled, glabrous; style very short and stout; stigmas 2–3. Ovules 2, pendulous from the apex of each cell.

Summit of Mount Roraima, 8600 ft., *im Thurn*, 334; *McConnell & Quelch*, 88, 318, 638.

This species differs from *Cyrilla antillana*, Michx., in having smaller and more rigidly coriaceous leaves, with the midrib not prominent beyond the middle on the underside, shorter and denser racemes, and longer and more acuminate sepals and petals.

LEGUMINOSÆ.

CROTALARIA ANAGYROIDES, H. B. & K. Nov. Gen. & Sp. vi. p. 404.
Kotinga Valley, *McConnell & Quelch*, 169.

TEPHROSIA ADUNCA, Benth. in Ann. Nat. Hist. Ser. I. iii. (1839), p. 432.
Kotinga Valley, *McConnell & Quelch*, 131, 199.

CLITORIA GUYANENSIS, Benth. in Journ. Linn. Soc., Bot. ii. (1858), p. 40.
Kotinga Valley, *McConnell & Quelch*, 155; Ireng Valley, *McConnell & Quelch*, 209.

DIOCLEA GUIANENSIS, Benth. in Ann. Wien. Mus. ii. (1838), p. 134.
Kotinga Valley, *McConnell & Quelch*, 158.

PHASEOLUS SEMIERECTUS, Linn. Mant. i. p. 100, var.
Kotinga Valley, *McConnell & Quelch*, 171.

PHASEOLUS LASIOCARPUS, Mart. (?) *ex* Benth. in Ann. Wien. Mus. ii. (1838), p. 140,
Kotinga Valley, *McConnell & Quelch*, 177.

ERIOSEMA CRINITUM, Benth. in Hook. Journ. Bot. ii. (1840), p. 62.
Kotinga Valley, *McConnell & Quelch*, 186.

DIPTERYX OPPOSITIFOLIA, Willd. Sp. Pl. iii. p. 910.
Arabapu River, *McConnell & Quelch*, 143, 303. Roraima Range, 3500 ft., *McConnell & Quelch*, 717.—Guiana and Brazil.

Cassia insignis, N. E. Brown, sp. n. Foliola bijuga, ampla, oblique oblonga vel elliptico-oblonga, breviter obtuse acuminata, venosa, glandula magna inter inferiora. Stipulæ foliaceæ, falcato-lanceolatæ. Racemi laxe subcorymbosi. Pedicelli elongati. Stamina perfecta 7; staminodia 3. Antheræ perfectæ subæquales, 3 inferiores breviter rostratæ.

Leaves large, bijugate; petiole below the basal pair of leaflets, $\frac{3}{4}$–1 in. long, minutely puberulous, becoming nearly glabrous; leaflets obliquely oblong or elliptic-oblong, shortly and obtusely acuminate, obliquely rounded at the base, glabrous to the eye, but with a minute scattered pubescence as seen under a lens, with the veins and veinlets very conspicuous on both sides; the basal pair $1\frac{1}{2}$–$3\frac{1}{4}$ in. long, $\frac{3}{4}$–$1\frac{3}{4}$ in. broad; the terminal pair 4–9 lin. distant, $2\frac{3}{4}$–$4\frac{1}{2}$ in. long, 1–2 in. broad; gland $1\frac{1}{2}$ lin. long, 1 lin. thick, erect, ovoid, obtuse, placed between the basal pair of leaflets. Stipules leafy, $\frac{1}{2}$–$\frac{3}{4}$ in. long, 2–4 lin. broad, falcate-lanceolate, obtuse or acute, tapering at the base into a curved petiole. Racemes loosely subcorymbose at the ends of the branches, solitary or in pairs from the axils of the uppermost reduced leaves, $1\frac{1}{2}$–3 in. long, 7–14-flowered, softly and minutely pubescent. Pedicels 1–$1\frac{3}{4}$ in. long, pubescent. Sepals about $5\frac{1}{2}$ lin. long, $\frac{1}{4}$ in. broad, obovate, obtuse, puberulous, minutely ciliate towards the apex. Petals 8–11 lin. long, 4–8 lin. broad, elliptic or elliptic-obovate, very distinctly clawed, minutely puberulous on both sides. Stamens with 7 subequal perfect and 3 reduced abortive anthers, 3 of the perfect anthers shortly beaked. Ovary linear, curved, densely pubescent with yellowish adpressed hairs. Legume not seen.

On the upper slopes of Mount Roraima, *McConnell & Quelch*, 23.

Allied to *C. latifolia*, G. F. W. Mey., but may be at once distinguished by its narrow-based, petiolate stipules, and much longer pedicels.

Cassia Apoucouita, Aubl. Pl. Guian. i. p. 379, t. 146.

Mazaruni River, 300 ft., *McConnell & Quelch*, 716.

This appears to be the true plant of Aublet, which is easily distinguished from the Brazilian plants described by Bentham as *C. Apoucouita*, by its narrowly winged petiole and differently shaped leaflets. The *C. Apoucouita* of Bentham appears to me to include 2 or 3 perfectly distinct species.

Cassia hispidula, Vahl, Eclog. Am. iii. p. 10.

Kotinga Valley, *McConnell & Quelch*, 170. Ireng Valley, *McConnell & Quelch*, 246.

Cassia polystachya, Benth. in Hook. Journ. Bot. ii. (1840), p. 77; R. Schomb. Reisen in Brit.-Guiana, ii. pp. 187, 207, and iii. p. 1207.

Ireng Valley, *McConnell & Quelch*, 229. Upper slopes of Mount Roraima, *McConnell & Quelch*, 317.—Only known from this western corner of British Guiana.

Cassia uniflora, Spreng. Neue Entdeck. i. p. 291.

Kotinga Valley, near Roraima, *McConnell & Quelch*, 133. Kotinga Valley, *McConnell & Quelch*, 151. Savannahs generally, *McConnell & Quelch*, 320.

CASSIA RORAIMÆ, Benth. in Trans. Linn. Soc. xxvii. (1871), p. 574; Oliver in Trans. Linn. Soc. Ser. II. ii. (1887) p. 273.

Kotinga Valley, *McConnell & Quelch*, 140. Roraima Range, 3500 ft., *McConnell & Quelch*, 719.—Only known from this region.

MIMOSA MICROCEPHALA, Humb. & Bonpl. *ex* Willd. Sp. Pl. iv. p. 1039.

Kotinga Valley, *McConnell & Quelch*, 173.

PITHECOLOBIUM FERRUGINEUM, Benth. in Hook. Lond. Journ. Bot. iii. (1844), p. 208; R. Schomb. Reisen in Brit.-Guiana, iii. p. 1038.

Upper and lower slopes of Mount Roraima, *McConnell & Quelch*, 19. Roraima Range, 3500 ft., *McConnell & Quelch*, 712.—Endemic.

The fruit described by Bentham under *P. ferrugineum* in Trans. Linn. Soc. xxx. (1875) p. 584, does not belong to that species, but to some totally different plant.

ROSACEÆ.

MOQUILEA TURIUVA, Hook. f. in Mart. Fl. Bras. xiv. pt. II. p. 25.

Savannahs generally, *McConnell & Quelch*, 308.

HIRTELLA AMERICANA, Linn. Sp. Pl. ed. 1, p. 34.

Savannahs generally, *McConnell & Quelch*, 309.

RUBUS URTICÆFOLIUS, Poir. Encycl. vi. p. 246.

Upper slopes of Mount Roraima, *McConnell & Quelch*, 11.—Widely dispersed throughout Tropical America.

It is uncertain whether *R. Schomburgkii*, Klotzsch, in R. Schomb. Reisen in Brit.-Guiana, iii. p. 1102, is a synonym of this species or identical with *R. guyanensis*, Focke, in Brem. Abh. iv. (1874), p. 160, as no description is given by Klotzsch, and Schomburgk collected both species.

SAXIFRAGACEÆ.

WEINMANNIA GUYANENSIS, Klotzsch, in R. Schomb. Reisen in Brit.-Guiana, iii. p. 1089; Engler, in Linnæa, xxxvi. (1870), p. 605; Oliver, in Trans. Linn. Soc. Ser. II. Bot. ii. (1887), p. 273.

Summit of Mount Roraima, *McConnell & Quelch*, 92, 636.—Endemic.

The foliage of this plant is somewhat variable. In some examples the leaves are all trifoliolate, this being the typical form; in others they all consist of one leaflet only, whilst others have trifoliolate and unifoliolate leaves on the same branch.

WEINMANNIA FAGARIOIDES, H. B. & K. Nov. Gen. & Sp. vi. p. 54.

W. glabra, Linn. f. *var.* ?, Oliver, in Trans. Linn. Soc. Ser. II. Bot. ii. (1887), p. 273.

Summit of Mount Roraima, *McConnell & Quelch*, 639.—Also on the Andes of Peru, Bolivia, and Ecuador, from 6000–10,000 ft. elevation.

The specimens collected by im Thurn upon Roraima have longer leaves, with more numerous and narrower leaflets and longer and more lax racemes than those of the present collections; but I believe both forms belong to *Weinmannia fagarioides*, H. B. & K., which seems to be somewhat variable in the characters mentioned.

DROSERACEÆ.

DROSERA COMMUNIS, A. St. Hil. Pl. Rem. Bres. p. 267; Oliver, in Trans. Linn. Soc. Ser. II. Bot. ii. (1887), p. 273.

D. Roraimæ, Klotzsch, in R. Schomb. Reisen in Brit.-Guiana, iii. p. 1090.

Upper slopes of Mount Roraima, *McConnell & Quelch*, 42. Summit of Mount Roraima, *McConnell & Quelch*, 85, 681. Arabapu River, *McConnell & Quelch*, 154.—Widely distributed in eastern South America, westward to New Granada, and southward to Paraguay.

MYRTACEÆ.

CAMPOMANESIA COÆTANEA, Berg, in Mart. Fl. Bras. xiv. pt. I. p. 44.

Kanuku Mountains, *McConnell & Quelch*, 275.

MYRTUS MYRICOIDES, H. B. & K. Nov. Gen. & Sp. vi. p. 131, t. 539.

M. sp. nov. aff. myricoides, Oliver, in Trans. Linn. Soc. Ser. II. Bot. ii. (1887), p. 273.

Summit of Mount Roraima, *McConnell & Quelch*, 495.—Also in the Andes of Colombia up to 11,000 ft. elevation.

This was considered to be a new species by Prof. Oliver, but I cannot distinguish it by any specific character from *M. myricoides*, H. B. & K.

MYRTUS RORAIMENSIS, N. E. Brown, sp. n. Omnino glabra. Folia parva, anguste oblonga vel oblongo-lanceolata, obtusa, coriacea, utrinque glanduloso-punctata, supra nitida, rugulosa. Flores axillares. Petala orbicularia, glanduloso-punctata. Stamina quam petala breviora. Ovarium 3-loculare.

A branching shrub, quite glabrous in all parts. Leaves small, 4–6 lin. long, including the ½–1 lin. long petiole, 1½–3½ lin. broad, usually narrowly oblong or oblong-lanceolate, occasionally ovate, obtuse, rounded at the base, rigidly coriaceous, shining and rugulose above in the dried state, pale beneath, gland-dotted on both sides. Flowers axillary, solitary. Pedicels 1½–3 lin. long, bibracteolate at the apex. Bracteoles 1½–1¾ lin. long, ⅓–½ lin. broad, linear or linear-lanceolate, obtuse, coriaceous, gland-dotted. Calyx-tube ¾ lin. long, hemispherical; lobes about 1 lin. long, ⅔–¾ lin. broad, oblong or ovate-oblong, obtuse, gland-dotted. Petals about 2 lin. long and broad, suborbicular, very obtuse, gland-dotted. Stamens shorter than the petals. Ovary 3-celled; ovules several in each cell. Berry drooping, globose, about 3 lin. diam., crowned with the calyx-lobes.

Summit of Mount Roraima, 8600 ft., *McConnell & Quelch*, 635, 641.

This species somewhat resembles *M. myricoides*, H. B. & K., but differs in having perfectly glabrous stems, smaller, narrower, and less acute leaves, shorter pedicels, and smaller calyx-lobes.

LECYTHIS VENUSTA, Miers, in Trans. Linn. Soc. xxx. (1874), p. 214.

Mazaruni River, 200 ft., *McConnell & Quelch*, 713.

MELASTOMACEÆ.

MICROLICIA BRYANTHOIDES, Oliver, in Trans. Linn. Soc. Ser. II. Bot. ii. (1887), p. 274 t. 39. f. B; Cogn. in DC. Monog. Phan. vii. p. 49.

Summit of Mount Roraima, *McConnell & Quelch*, 630.—Endemic.

RHYNCHANTHERA GRANDIFLORA, DC. Prod. iii. p. 107.

Ireng Valley, *McConnell & Quelch*, 230.

SIPHANTHERA MICROLICIOIDES, Cogn. in Mart. Fl. Bras. xiv. pt. III. p. 199; and in DC. Monog. Phan. vii. p. 113.

Meisneria cordifolia, Benth. in Hook. Journ. Bot. ii. (1840), p. 299; R. Schomb. Reisen in Brit.-Guiana, iii. p. 1101.

M. microlicioides, Naud. in Ann. Sc. Nat. Sér. III. xii. (1849), p. 204; Oliver, in Trans. Linn. Soc. Ser. II. Bot. ii. (1887), p. 274.

Upper slopes of Mount Roraima, *McConnell & Quelch*, 8. Kotinga Valley, *McConnell & Quelch*, 182.—Apparently endemic in the Roraima region.

DESMOSCELIS VILLOSA, Naud. in Ann. Sc. Nat. Sér. III. xiii. (1850), p. 30.

Kotinga Valley, *McConnell & Quelch*, 195.

MACAIREA ASPERA, N. E. Brown, sp. n. (Plate 2.) Folia oblonga, obtusa, supra scaberrima, subtus appresse rufo-tomentosa. Calyx appresse pubescens et glandulosus. Petala obovato-oblonga, obtussisima, glanduloso-ciliata. Staminum filamenta superne glandulosa. Ovarium superne dense glandulosum, stylo parce glanduloso.

A branching shrub; clothed on the young shoots, branches of the panicle, pedicels and calyx with rather long, rust-coloured, adpressed hairs. Leaves opposite; petiole 4–6 lin. long, pubescent like the stems; blade $1\frac{1}{4}$–3 in. long, 8–17 lin. broad, oblong, obtuse, or shortly and stoutly apiculate, cuneately rounded into the petiole at the base, coriaceous, 3-nerved, with the lateral nerves close to the revolute margin, scabrid with minute, conical, hair-tipped tubercles on the upper surface, tomentose beneath with a dense adpressed pubescence of rust-coloured hairs. Panicles 4–6 in. long, 2–$3\frac{1}{2}$ in. broad, many-flowered. Pedicels 1–$2\frac{1}{2}$ lin. long, minutely bibracteolate in the middle. Calyx with sessile glands mingled with the hairs outside; tube campanulate, $1\frac{1}{2}$ lin. long; lobes $1\frac{1}{2}$ lin. long, deltoid, acuminate. Petals 3–4 lin. long, $2\frac{1}{2}$–3 lin. broad, oblong-ovate, very obtuse, minutely gland-ciliate, glabrous. Stamens glandular on the apical part of the filaments. Anthers with the connective dilated at the base into a cordate-orbicular shield. Ovary free, densely covered with glands on the upper part; style filiform, sparsely glandular.

Upper slopes of Mount Roraima, *McConnell & Quelch*, 31.

Another specimen (no. 24, *McConnell & Quelch*), collected at the same place as no. 31, is identical with it in all particulars excepting the anthers, in which the portion of the connective between the pollen-cells and the dilated base is very much longer than in 31, as shown in figs. 6–7, but I cannot consider this variation of sufficient importance to separate the two specifically.

Allied to *Macairea thyrsiflora*, DC., and *M. albiflora*, Cogn.; differing in the very much rougher upper surface and different indumentum of the lower surface of the leaves and in the stouter anthers. *M. albiflora*, Cogn., according to Spruce's label, has purple flowers, not white as described by Cogniaux.

MACAIREA PACHYPHYLLA, Benth. in Hook. Journ. Bot. ii. (1840), p. 292; R. Schomb. Reisen in Brit.-Guiana, iii. pp. 1100, 1192; Cogn. in DC. Monog. Phan. vii. p. 178.

Kotinga Valley, *McConnell & Quelch*, 181.—Apparently endemic to the vicinity of Roraima.

TIBOUCHINA FRATERNA, N. E. Brown, sp. n. Folia anguste elliptica, utrinque æqualiter subacuta, 3-nervia, subtus appresse squamosa, supra striolata, et marginibus et secundum lineas duas inter nervos squamosa. Bracteæ liberæ, oblongæ, obtusæ. Calyx appresse squamosus, 5-lobus, tubo cylindrico quam lobis longiore. Petala elliptico-obovata, unguiculata, glanduloso-ciliata.

Branchlets densely clothed with imbricating, lanceolate, acuminate, brownish scales about $\frac{1}{2}$ lin. long, those at the nodes about twice as long and more acuminate. Leaves spreading; petiole 1–1$\frac{1}{2}$ lin. long, scaly; blade $\frac{3}{4}$–1 in. long, 4–6 lin. broad, narrowly elliptic, about equally acute or subacute at both ends, apiculate, 3-nerved, the underside clothed with adpressed acuminate scales, those on the nerves much larger than the rest, the upper surface finely striate, with a longitudinal row of minute scales near each of the lateral nerves and along the margins. Cymules 2–3-flowered, subsessile or with peduncles up to 3$\frac{1}{2}$ lin. long, axillary and terminal, forming a terminal inflorescence 1–2 in. long, 1 in. broad, clothed to the tips of the calyx-lobes with pale, rosy-tinted acuminate scales. Bracts free, 2–4 lin. long, about 1$\frac{1}{2}$ lin. broad, oblong, obtuse, resembling reduced leaves; bracteoles smaller, thinner, more glabrous, free, ciliate with long hair-like scales. Pedicels very short, scarcely 1 lin. long. Calyx-tube 3 lin. long and about 1$\frac{1}{2}$ lin. diam., cylindric-campanulate; lobes 2 lin. long, 1$\frac{1}{4}$ lin. broad at the base, whence they gradually taper in a nearly straight line to an acute point, erect or very slightly spreading, glabrous inside, ciliate. Petals 7 lin. long, 3$\frac{1}{2}$ lin. broad, elliptic-obovate, very obtuse, clawed, minutely ciliate with gland-tipped hairs, and with a few long simple hairs at the apex, otherwise glabrous. Stamens 10, unequal, glabrous; the longer anthers 5 lin. long, the shorter 4 lin. long, all attenuate to a subulate point, opening by one terminal pore; connective bifid at its insertion on the filament. Ovary free, oblong, densely covered with hair-like scales; style slender, glabrous.

Upper slopes of Mount Roraima, *McConnell & Quelch*, 17.

A very distinct species, which, according to the arrangement of Cogniaux, I think should be placed in the section *Lepidotæ*, although it bears very little resemblance to the only two species (*T. lepidota*, Baill., and *T. paleacea*, Cogn.) at present placed under that section. It has much more resemblance to *T. Spruceana*, Cogn., and *T. aspera*, Aubl., but the free (not connate) bracts and bracteoles at once separate it from the section to which they belong.

TIBOUCHINA LASIOPHYLLA, Cogn. in Mart. Fl. Bras. xiv. pt. III. p. 297; and in DC. Monog. Phan. vii. p. 270.

Pterolepis lasiophylla, Triana, in Trans. Linn. Soc. xxviii. (1871), p. 40; Oliver, in Trans. Linn. Soc. Ser. II. Bot. ii. (1887), p. 274.

Kotinga Valley, *McConnell & Quelch*, 183, 197. Ireng Valley, *McConnell & Quelch*, 205. Slope of Mount Roraima, at 5400 ft. *im Thurn*, 59.—Only known from the above localities.

TIBOUCHINA ASPERA, Aubl. Pl. Guian. i. p. 446, t. 177; R. Schomb. Reisen in Brit.-Guiana, iii. pp. 1100, 1191.

Pleroma tibouchinum, Triana, in Trans. Linn. Soc. xxviii. (1871), p. 45, t. 3; Oliver, in Trans. Linn. Soc. Ser. II. Bot. ii. (1887), p. 274.

Ireng Valley, *McConnell & Quelch*, 217.—Widely spread in Tropical South America, extending westward to Colombia and Peru.

MARCETIA TAXIFOLIA, DC. Prod. iii. p. 124; R. Schomb. Reisen in Brit.-Guiana, ii. p. 216, and iii. p. 1100; Oliver, in Trans. Linn. Soc. Ser. II. Bot. ii. (1887), p. 273.

Upper slopes of Mount Roraima, *McConnell & Quelch*, 13, 20; *im Thurn*, 68; *Appun*, 1114, 1153. Kotinga Valley near Roraima, *McConnell & Quelch*, 149.

With the exception of the above localities, this species is only known from Brazil, where it is a common and widely spread plant.

MARCETIA JUNIPERINA, DC. Prod. iii. p. 125; Oliver, in Trans. Linn. Soc. Ser. II. Bot. ii. (1887), p. 274.

Summit of Mount Roraima, *McConnell & Quelch*, 86, 644.—Also in Venezuela at Cumana and Merida.

CHÆTOLEPIS ANISANDRA, Naud. in Ann. Sc. Nat. Sér. III. xiv. (1850), p. 140; Cogn. in DC. Monog. Phan. vii. p. 171.

On the face of the cliff of Mount Roraima, at 7000–8000 ft., *McConnell & Quelch*, 22.—Endemic.

MONOCHÆTUM BONPLANDII, Naud. in Ann. Sci. Nat. Sér. III. xiv. (1850), p. 51; Oliver, in Trans. Linn. Soc. Ser. II. Bot. ii. (1887), p. 274; Cogn. in DC. Monog. Phan. vii. p. 393.

Kotinga Valley, *McConnell & Quelch*, 189.—Also in Venezuela, Colombia, Ecuador, and Peru.

MICONIA HOLOSERICEA, DC. Prod. iii. p. 181.

M. albicans, Steud. Nom. ed. 2, ii. p. 139.

Upper slopes of Mount Roraima, *McConnell & Quelch*, 28.—Throughout Tropical America from Mexico to Paraguay.

Miconia tinifolia, Naud. in Ann. Sc. Nat. Sér. III. xvi. (1851), p. 225.

Kotinga Valley, *McConnell & Quelch*, 191. Summit of Mount Roraima, *McConnell & Quelch*, 633.—Also in Venezuela.

LYTHRACEÆ.

Cuphea gracilis, H. B. & K. Nov. Gen. & Sp. vi. p. 199, var. **media**, Koehne, in Mart. Fl. Bras. xiii. pt. II. p. 284.

Ireng Valley, *McConnell & Quelch*, 225.

ONAGRACEÆ.

Jussiæa longifolia, DC. in Mém. Soc. Phys. Genèv. ii. pt. II. (1824), p. 141.

Ireng Valley, *McConnell & Quelch*, 208, 214, 227.

TURNERACEÆ.

Turnera ulmifolia, Linn. Sp. Pl. ed. 1, p. 271.

Kotinga Valley, *McConnell & Quelch*, 174. Ireng Valley, *McConnell & Quelch*, 256, 260.

Turnera velutina, Benth. in Hook. Journ. Bot. iv. (1842), p. 116.

Ireng Valley, *McConnell & Quelch*, 240.

Piriqueta guianensis, N. E. Brown, sp. n. Perennis, caulibus simplicibus, pilis stellatis cum setulis intermixtis tomentosa. Folia petiolata, anguste vel oblongo-lanceolata, obtusa, obtuse dentata, dense tomentosa. Flores axillares, solitarii. Pedicelli 4–10 lin. longi, supra medium articulati. Petala purpurea ?, glabra. Fructus globosus, dense appresse pubescens. Semina oblonga, reticulato-foveolata.

A perennial herb growing to about 1 ft. high. Stems several from the same rootstock, rather slender, usually simple, tomentose with a short down of stellate hairs intermingled with longer spreading hairs. Leaves petiolate; petiole 1–2 lin. long, blade ½–1 in. long, 1½–4 lin. broad, narrowly oblong or oblong-lanceolate, obtuse, obtusely 3–6-toothed on each side, densely stellate tomentose on both sides. Flowers axillary, solitary. Pedicels 4–10 lin. long, jointed above the middle, stellate-tomentose. Calyx 3–4½ lin. long, stellate-tomentose outside; tube about 1 lin. long, shortly obconical, lobes 2–3½ lin. long, 1–1½ lin. broad, ovate-lanceolate or lanceolate, acute. Petals much longer than the calyx, obovate, glabrous, with a fringed scale at their base, apparently purple. Stamens about 2¼ lin. long, with glabrous filaments. Ovary ovoid, densely adpressed-pubescent, not tubercled; styles 2 lin. long, with a few scattered hairs or almost glabrous; stigmas dilated. Capsule globose, about 2 lin. diam., 3-valved, densely covered with adpressed, rather silky hairs. Seeds 1 lin. long, oblong, rather coarsely pitted, pale reddish brown.

British Guiana; without precise locality, *Appun*, 1858. Ireng Valley, *McConnell & Quelch*, 264.

Allied to *P. Duarteana*, Urb.

PIRIQUETA VILLOSA, Aubl. Pl. Guian. i. p. 298, t. 117.

P. cistoides, Mey. *ex* Steud. Nom. ed. 2, ii. p. 344.

Kotinga Valley, *McConnell & Quelch*, 178.

PASSIFLORACEÆ.

PASSIFLORA QUELCHII, N. E. Brown, sp. n. (Plate 3.) Frutex vel arbor, glaber. Folia petiolata, cuneato-oblonga, acuta vel obtusissima, undulata, coriacea; petiolus apice biglandulosus. Stipulæ minutæ, subulatæ, deciduæ. Cirrhi nulli. Flores in racemum abbreviatum dispositi, glabri. Calycis tubus elongatus, cylindricus. Sepala petalis subconformia, oblongo-lanceolata, obtusa. Corona faucialis uniserialis, multipartita, segmentis complanatis prope apicem dilatatis oblique acuminatis; corona interior e tubo versus basin emergens, multipartita, segmentis complanatis lineari-falcatis.

Shrubby or arborescent, not climbing; branches woody, glabrous. Leaves simple, entire, very coriaceous, 2–4 lin. distant, spreading, glabrous; petiole 4–6 lin. long, moderately stout, with two large sessile glands at the apex; blade 3–5 in. long, ¾–1½ in. broad, cuneately oblong, gradually tapering from ¾ the way up in a slightly curved line to an acute base, shortly acute or very obtuse and slightly emarginate with an apiculus in the notch, with strongly undulated margins; primary lateral veins 12–15 on each side of the midrib, very spreading, uniting close to the margin in a series of broad loops; secondary veins much reticulated, all prominent on both sides. Stipules minute, subulate, very deciduous. Tendrils none. Flowers in short racemes or clusters, probably on the older parts of the branches; axis of the inflorescence ⅓–¾ in. long, several-flowered, glabrous. Pedicels 1–2 lin. long, glabrous. Calyx-tube about 1 in. long, 1½–2 lin. diam. in the dried state, cylindric, slightly enlarged at the mouth, glabrous; the lobes 10–12 lin. long, 2⅓–3½ lin. broad, oblong-lanceolate, obtuse or subacute. Petals similar to the calyx-lobes and of about the same size. Corona in two series; one placed towards the bottom of the calyx-tube, consisting of numerous linear-falcate, acute, erect filaments about 1½ lin. long; the other at the mouth of the tube, consisting of numerous flattened, somewhat hatchet-shaped segments rather more than ½ in. long, with the dilated part slightly toothed and dorsally produced into a short point. Gynophore nearly 1½ in. long, terete or perhaps sulcate at the base, glabrous. Filaments of the stamens 2 lin. long. Ovary oblong, 9-striate; styles 2 lin. long, stigmas capitate.

Ireng Valley, *McConnell & Quelch*, 207.

A very distinct species, easily distinguished from all the others of shrubby habit by its cuneately oblong, undulated leaves, shortly racemose flowers, and long calyx-tube, besides other characters.

ARALIACEÆ.

DIDYMOPANAX RUGOSUM, N. E. Brown, sp. n. Folia 3-foliolata, foliolis ellipticis vel elliptico-oblongis utrinque obtusis, rigide coriaceis, supra glabris rugosis, subtus dense tomentosis. Umbellæ compositæ, longe pedunculatæ, fulvo-tomentosæ, multifloræ. Petala ovata, acuta. Drupa immatura valde compressa, suborbiculata.

Leaves digitately trifoliolate; petiole stout, $\frac{1}{4}$ in. thick, tomentose, broken in the only specimen seen and about $3\frac{1}{2}$ in. long; leaflets rigidly coriaceous, above glabrous and rugose, with a narrow prominent midrib and impressed veins and veinlets, beneath tomentose on the very stout prominent midrib and the primary veins, and covered with a dense blanket-like tawny tomentum between them; the lateral pair $3\frac{1}{2}$–4 in. long, $2\frac{1}{2}$–$2\frac{3}{4}$ in. broad, elliptic, obtuse at both ends, mucronulate, with stout petiolules about 2 lin. long; the terminal leaflet $4\frac{3}{4}$ in. long, $2\frac{3}{4}$ in. broad, elliptic-oblong, slightly emarginate at the obtuse apex, mucronulate, with a stout petiole 4 lin. long. Umbel very compound, 6–8-rayed, many-flowered, $2\frac{3}{4}$–$3\frac{1}{2}$ in. diam., with a stout, more or less flattened peduncle 4–7 in. long, 2–3 lin. thick, everywhere, to the outside of the petals, densely covered with a tawny tomentum, becoming greyish with age. Secondary umbels 6–7-rayed, some of the rays bearing a single flower, others dividing into tertiary umbels, some of which again divide in a similar manner, forming 2–4-flowered umbels of a fourth order. Bracts and bracteoles suborbicular, about $\frac{1}{2}$–1 lin. diam. Pedicels $1\frac{1}{2}$–2 lin. long, stout, not jointed. Calyx-limb shortly cupular, 5-toothed; teeth $\frac{1}{4}$–$\frac{1}{3}$ lin. long, deltoid, acute. Bud globose. Petals 5, about $\frac{3}{4}$ lin. long, and nearly as broad, deltoid-ovate, acute, rather thick, glabrous within. Stamens 5, not longer than the petals. Ovary 2-celled; styles 2, somewhat flattened, divergent in young fruit, which is suborbicular in outline and compressed.

Summit of Mount Roraima, 8600 ft., *McConnell & Quelch*, 663.

A most distinct species, in general habit more like *Didymopanax Spruceanum*, Seem., than any other; but the very thick rigid leaves, rugose above and tomentose beneath, at once distinguish it from that and all others.

Sciadophyllum umbellatum, N. E. Brown, sp. n. Folia digitata, foliolis 6–8 petiolulatis oblongo-lanceolatis vel oblanceolato-oblongis obtuse acutis basi cuneatis supra glabris subtus tomento appresso pallido vestitis. Umbellæ compositæ, longissime pedunculatæ, multifloræ. Petala ovata, acuta. Fructus immaturus 5-angularis, compressus.

Leaves digitately 6–8-foliolate; petiole 4–6 in. long, $1\frac{1}{2}$–2 lin. thick, glabrous; leaflets coriaceous, unequal, $2\frac{1}{2}$–6 in. long, excluding the 2–7 lin. long petiolules, 1–$2\frac{1}{4}$ in. broad, oblong-lanceolate or oblanceolate-oblong, obtusely pointed at the apex, cuneate at the base, entire or very slightly repand, slightly revolute along the margins, glabrous above, with a thin layer of pale close tomentum beneath; midrib prominent on both sides, stouter beneath; primary lateral veins 9–16 on each side of the midrib, rather slender and not very prominent. Umbel compound, 2–3 in. diam., on a peduncle 9–12 in. long, $2\frac{1}{2}$ lin. thick; rays numerous, unequal, $\frac{1}{2}$–$1\frac{1}{4}$ in. long, $\frac{3}{4}$–1 lin. thick. Bracts minute, rounded. Secondary umbels 10–16-flowered. Pedicels 1–$1\frac{3}{4}$ lin. long. Calyx-limb annular, entire or very minutely 5-toothed. Petals 5, acute. Stamens 5, not exceeding the petals. Ovary 3–5-celled; style or column of united styles $1\frac{1}{3}$ lin. long, minutely 3–5-fid at the apex. Young fruit deeply 3–5-angled, angles compressed.

Summit of Mount Roraima, 8600 ft. *McConnell & Quelch*, 666.

Allied to *S. coriaceum*, Marchal, from which it differs in its more pointed leaves, very much shorter and stouter pedicels, and different indumentum. The indumentum which covers the whole of the inflorescence is rather peculiar, and is neither scurfy nor hairy, and when highly magnified seems to consist of a very thin dense covering of very minute, flattened, and very closely adpressed hairs, producing a greyish hue.

This species and *Sciadophyllum coriaceum* differ from all the others in the genus in having the flowers collected into a compound umbel terminating a long peduncle, and not paniculate; for although *S. coriaceum* has a second whorl of umbels below the terminal one, they all spring from one level, and the inflorescence cannot be called a panicle. The styles also of these two species are united in a column, and in this character, and indeed in their entire floral structure, they quite agree with *Heptapleurum*, a genus that is only artificially separated from *Sciadophyllum* by this one point, as has already been pointed out in Benth. & Hook. f. Genera Plantarum, i. pp. 940, 942. As there are some species of *Heptapleurum* in which the styles are at first united in a column and during the growth of the young fruit become free, it appears to me that *Sciadophyllum* should include *Heptapleurum*, when it would form a genus fairly uniform in character and of world-wide distribution within the tropics.

RUBIACEÆ.

HENRIQUEZIA JENMANI, K. Schum. in Mart. Fl. Bras. vi. pt. VI. p. 135. (Plate 4.) Mazaruni River, *McConnell & Quelch*, 711; *Jenman*, 629.

This handsome tree appears only to have been collected in this single locality.

CHALEPOPHYLLUM SPECIOSUM, N. E. Brown, sp. n. (Plate 5, figs. 10–17.) Frutex glaber, ramis tetragonis. Folia opposita ad apicem ramorum subconferta, coriacea, sessilia, obovata, obtusa, subapiculata. Flores in axillis supremis (foliis delapsis) solitarii, breviter pedicellati, bibracteati. Calycis lobi æquales vel inæquales, lineares vel oblongi, acuti. Corolla hypocrateriformis, 5-lobata, tubo longissimo, lobis anguste lanceolatis vel oblongis acutis. Stamina inclusa. Stylus sæpius inclusus.

A stoutly-branched shrub, glabrous in all parts excepting the inside of the corolla. Branches 4-angled, 2 lin. thick; internodes very short, 1½–5 lin. long. Leaves opposite, in a cluster of 3–5 pairs at the tips of the branches, subsessile, 1¼–2 in. long, ½–1 in. long, more or less obovate, obtuse, bluntly apiculate, cuneate at the base, rigidly coriaceous in the dried state, shining above, pale beneath, slightly revolute along the margins; midrib stout and conspicuous beneath; veins inconspicuous or not at all visible. Stipules broad-based, abruptly contracted into a linear point about 1½ lin. long, persistent long after the leaves have fallen. Flowers usually 2 to each shoot, or sometimes 1 only, arising immediately below the terminal tuft of leaves in the axils of fallen leaves or in those of the lowest pair, solitary in each axil. Pedicels 1–4 lin. long, stout, flattened, bibracteate at the base of the ovary. Bracts 4–8 lin. long, 1½–5 lin. broad, of the form and substance of reduced leaves. Calyx-lobes 5–10 lin. long, 1–2½ lin. broad, equal or unequal, varying from linear to oblong, acute, erect, coriaceous. Corolla very variable in size, hypocrateriform, regular, 5-lobed; tube 1¾–3½ in. long, about 1½ lin.

diam., cylindric, 5-grooved, slightly enlarged and densely hairy inside at the throat around the anthers; lobes spreading or recurved, 1–2 in. long, 2–6 lin. broad, linear-lanceolate or oblong, acute, glabrous, contorted in the bud. Stamens 5, included, inserted in the throat of the corolla-tube; filaments about 2½ lin. long; anthers 3–3½ lin. long, dorsifixed, with a rather long and broad attachment to the filaments, linear, acute, bifid at the base, glabrous. Ovary 2½–3 lin. long, stoutly obconical, 2-celled; style about as long as the corolla-tube, or shorter than the anthers or rarely exserted, glabrous; stigma of two oblong obtuse lobes about 1 lin. long. Ovules numerous, flattened, on broad placentas that are peltately attached along their middle by a very short narrow plate to the septum. Fruit not seen.

Summit of Mount Roraima, 8600 ft., *McConnell & Quelch,* 100, 305, 653.

The variation in the length of the style would seem to imply that the flowers are heterostyled, but it may be due to a lengthening at various periods of development. The stems in the figure on Plate **5** are not represented of sufficient stoutness.

SIPANEA PRATENSIS, Aubl. Pl. Guian. i. p. 147, t. 56; im Thurn & Oliver, in Trans. Linn. Soc. ser. II. ii. (1887), pp. 261, 276.

Kotinga Valley, *McConnell & Quelch,* 175, 185, 198.—Widely distributed in eastern Tropical America from Trinidad to Minas Geraes and westward to Colombia.

DIDYMOCHLAMYS CONNELLII, N. E. Brown, sp. n. (Plate **5**, figs. 1–9.) Folia alterna, oblique oblanceolata, subabrupte acuta, glabra. Bracteæ exteriores suborbiculares, brevissime cuspidatæ. Corollæ tubus supra medium ampliatus, ore contractus; lobi infra medium bilobulati lobulis lineari-oblongis undulatis subtortis.

A small herb, with a simple stem 1¼–6 in. long. Leaves alternate, distichous, 1–1⅓ in. long, including the very short petiole, 2½–4½ lin. broad, obliquely or subfalcately oblanceolate, acute or rounded in at the apex to a very short cuspidate point, tapering from above the middle to an unequal base, the upper side of which is very narrow and acute, and the lower side broadly rounded or subtruncate, glabrous on both sides; under surface pale, densely covered with large stomata, which appear as whitish dots under a lens; stipule solitary, 3–4 lin. long, linear, acuminate, glabrous. Peduncle terminal, about ¼ in. long, bearing two suborbicular, apiculate, glabrous bracts, about ½ in. in length and breadth, enclosing 2 (or more?) shortly pedicellate flowers and 1 (or more?) linear acute bracteole. Calyx-lobes slightly unequal, ¾–1 lin. long, lanceolate, acute, erect, glabrous. Corolla-tube about ½ in. long, probably somewhat compressed, dilated a little above the middle, then narrowed to the mouth, glabrous, with the exception of a ring of hairs inside near the base; lobes divided to slightly below the middle into two diverging, linear-oblong, obtuse, undulated and somewhat twisted lobules 1½ lin. long and rather more than ½ lin. broad, the basal entire part being about 1 lin. long and broad, deltoid-ovate, slightly concave, with a minute, obtuse, incurved point at the apex between the lobules. Stamens 5, included, inserted below the middle of the corolla-tube, unequal, 2 longer than the rest and inserted higher up, having on one side a pair and on the other side one of the shorter stamens alternating with them; filaments glabrous, anthers linear. Glands of the disk 4, in 2 opposite pairs, the larger pair partly enclosing the smaller pair. Ovary inferior, laterally compressed, 2-celled; style included, filiform; stigma of 2 short oblong lobes; placenta ascending from near the base of the septum, thin; ovules numerous, flat.

On the Roraima Range at 3500 ft., *McConnell & Quelch*, 714; Kaieteur Falls on the Potaro River, *Jenman*, 7462.

This is one of the most remarkable plants in the collection; its alternate leaves and general habit give it the appearance of a Gesneraceous rather than of a Rubiaceous plant. The two large bracts enclosing the flowers and the bilobed corolla-lobes are very remarkable characteristics. It is very closely allied to *Didymochlamys Whitei*, Hook. f., from New Granada, the only other known species, but differs in its much smaller leaves and very much longer corolla-lobules. In *D. Whitei* the leaves are 1¾–3½ in. long, 4–11 lin. broad, and taper at the apex into a long acuminate point, and the subquadrate lobules of the corolla are only about ½ a line long and the same in breadth.

To the generic characters of *Didymochlamys* may be added the following description of the fruit, taken from a specimen of *D. Whitei* sent to Kew by Mr. R. B. White in 1882:—Fruit a laterally-compressed 2-celled capsule, dehiscing at the apex between the glands; placentas ascending from near the base of the septum, thin; seeds numerous, minute, ovate, flattened, thinly covered with rather long hairs, with a dense tuft at the narrower (micropyle ?) end; testa rather coriaceous, moderately thin; albumen copious, oily; embryo minute.

The two smaller glands of the disk in the fruiting stage of *D. Whitei* are a little longer than the larger glands, they are tubular in the upper part and may assist in the dispersion of the seeds.

TOCOYENA NEGLECTA, N. E. Brown, sp. n. Folia breviter petiolata, lanceolata vel elliptico-lanceolata, acuta, basi cuneata, supra pubescentia, subtus tomentosa. Cymæ terminales, subsessiles, 9–20-floræ. Calyx acute 5-dentatus, plus minusve tomentosus. Corollæ tubus 3–3½ poll. longus, extra tomentosus, intra glaber, fauce hirtus; lobi oblique oblongo-lanceolati, subacuti, glabri, ciliati.

Branches subterete or obscurely 4-angled, with a light brown bark, tomentose when young. Leaves opposite, 3–7 in. long, 1¾–3½ in. broad, lanceolate, elliptic-lanceolate or slightly obovate, acute, cuneately tapering at the base into a petiole 1½–3 lin. long, somewhat harshly pubescent above, densely tomentose beneath, with the hairs along the veins distinctly diverging on either side; primary veins 9–13 on each side of the midrib, and together with the reticulated veinlets impressed above, prominent beneath. Stipules about 2 lin. long, triangular, acute, at first tomentose, becoming glabrous with age. Cymes terminal, subsessile, about 9–20-flowered. Flowers sessile. Calyx more or less tomentose; the tube 1½–2½ lin. long, oblong, slightly tapering downwards; the limb cup-shaped, with 5 deltoid acuminate teeth ¾–2 lin. long. Corolla hypocrateriform, 5-lobed, white; the tube 3–3½ in. long, about 1½ lin. diam., slightly enlarged at the mouth, tomentose outside, glabrous within, except in the throat, which is densely hairy; the lobes 10–12 lin. long, 5–6 lin. broad, obliquely oblong-lanceolate, subacute, glabrous on both sides, ciliate along the outer margin, but in the younger stage, when contorted into the lanceolate acuminate bud, the outside towards the base is more or less pubescent or tomentose. Anthers sessile at the mouth of the corolla-tube, partly exserted, 4 lin. long, oblong-lanceolate, obtuse. Ovary 2-celled; style as long as the corolla-tube, slender, glabrous; stigma of 2 oblong obtuse lobes, about 2 lin. long, 1 lin. broad. Fruit globose, about ¾ in. diam., thinly pubescent or subglabrous.

British Guiana: Maimatta on the Rupununi River, *Jenman*, 5525, 5742; Kotinga Valley, *McConnell & Quelch*, 163; Roraima, *Schomburgk*, 478; Suruma River, *Schomburgk*, 772 B.

Allied to *Tocoyena fœtida*, Poepp. & Endl., but differs in its much shorter petioles and corolla-tube. From *T. velutina*, Spruce (which is a very distinct species, wrongly referred to *T. fœtida* by K. Schumann), it differs in the less elliptic form of the leaves, in the indumentum, and very different calyx-limb. Schomburgk's specimens are quoted by K. Schumann in the 'Flora Brasiliensis,' vi. pt. VI. p. 348, under *T. formosa*, K. Schum., which is a quite different species, with orbicular leaves and short, ellipsoidal, obtuse buds.

RETINIPHYLLUM LAXIFLORUM, N. E. Brown. (Plate 6.) Folia petiolata, elliptica vel elliptico-oblonga, obtusa basi subcuneata, glabra. Racemus terminalis, 3–9-florus, floribus longe pedicellatis. Bracteoli sub ovario in cupulam disciformem minute denticulatam connati. Calyx non costatus, truncatus, minutissime 5-dentatus. Corolla utrinque sericeo-puberula, lobis reflexis tubo brevioribus.—*Patima laxiflora*, Benth. in Hook. Journ. Bot. iii. (1841) p. 220; R. Schomb. Reisen in Brit.-Guian. iii. p. 1142. *Synisoon Schomburgkianum*, Baill. in Bull. Soc. Linn. Paris (1879), p. 208; Baill. Hist. Pl. vii. p. 433; K. Schum. in Mart. Fl. Bras. vi. pt. VI. p. 398.

A shrub or tree, glabrous in all parts excepting the flowers, and exuding a varnish-like resin on various parts of the young branches and inflorescence. Branches moderately slender, with a brown bark. Leaves opposite, petiolate, thinly coriaceous; petiole 2–8 lin. long; blade 1½–4¾ in. long, 1–2¼ in. broad, shining above, paler beneath with distinctly reticulated veins. Stipules subtruncate, minutely apiculate. Raceme erect, terminal, very lax, 2–2¾ in. long, consisting of 1–4 pairs of opposite flowers and one terminal one. Bracts reduced to a minutely denticulate raised line. Pedicels 6–8 lin. long, ascending, slender. Bracteoles beneath the ovary connate into a very small, disk-like, minutely-denticulate involucel. Calyx 3½–4 lin. long, with the limb produced for 2–2⅓ lin. above the ovary, tubular, truncate, with 5 very minute distant teeth, glabrous, but more or less coated with the varnish-like secretion. Corolla erect, 5-lobed, minutely adpressed-pubescent outside and inside, with a dense ring of white hairs near the base of the tube inside, below which it is glabrous; tube 8–9 lin. long, 1¼–1⅓ lin. diam., cylindric; lobes pendulous, reflexed from their base, 7 lin. long, 1½ lin. broad, linear-oblong, obtuse, nearly straight along one margin curved along the other, strictly contorted in the bud. Stamens inserted at the mouth of the tube, reflexed with the corolla lobes; filaments 5 lin. long, pubescent; anthers 2 lin. long, dorsifixed, lanceolate, produced beyond the cells into a subulate point at the apex and into an oblong, emarginate, membranous appendage at the base, glabrous; pollen apparently red. Ovary 5-celled, surmounted by a rather deep ring-like disk; style much exserted, 1⅓ in. long, rather slender, pubescent; stigma slightly thickened, ovoid-conical, tipped with 5 minute points. Ovules 2 in each cell, collateral, axile, pendulous from near the top of the cell, and partly covered at the top by a cap-like outgrowth of the funicle-like placenta. Fruit a globose, ribbed berry about ¼ in. diam., crowned with the calyx-tube; endocarp hardened into 5 separable nutlets, 3-keeled on the back, triangular in transverse section, with a false cell under each lateral wing. Seeds not seen.

Aroie Creek, *im Thurn*, 6. Upper slopes of Mount Roraima, *McConnell & Quelch*, 18; *Appun*, 1175; *Schomburgk*, 724 (815 B), 158.

This very distinct species of *Retiniphyllum* appears to have been misunderstood by all authors. Originally it was doubtfully referred by Bentham to the genus *Patima*, and erroneously described as having very numerous seeds. Next, in Bentham and Hooker's 'Genera Plantarum,' ii. p. 98, it is confused with *Kutchubæa insignis*, Fisch., and the part of the generic description in that work, relating to the fruit, is drawn up from the present plant and not from the true *Kutchubæa*, which indeed it greatly resembles in habit, but differs in having a 5-lobed corolla, 5 exserted, reflexed stamens, with long filaments, a long exserted style, and in the presence of a minute disk-like involucel at the apex of the pedicel, which is jointed to the calyx; whilst in *Kutchubæa* the corolla is 8-lobed, the stamens are 8, with the anthers almost sessile and included in the throat of the corolla-tube, the style is included, and the pedicel is continuous with the calyx, without any trace of an involucel; the foliage and stipules of the two plants are also very different, besides disagreeing in several minor details. Finally Baillon made a distinct genus of it, which he placed next to *Knoxia*, where it has no affinity, for it is undoubtedly a true *Retiniphyllum*, allied to *R. scabrum*, Benth., but differing from that and all others of the genus by the long slender pedicels of its lax, few-flowered inflorescence. The involucel is characteristic of the genus *Retiniphyllum*.

PSYCHOTRIA CONCINNA, Oliver, in Trans. Linn. Soc. Ser. II. ii. (1887) p. 276, t. 42. f. B. Summit of Mount Roraima, *McConnell & Quelch*, 80, 89, 667.—Endemic.

PSYCHOTRIA CRASSA, Benth. in Hook. Journ. Bot. iii. (1841), p. 227; im Thurn & Oliver, in Trans. Linn. Soc. Ser. II. Bot. ii. (1887), pp. 265, 276; R. Schomb. Reisen in Brit.-Guiana, iii. p. 945.

Summit of Mount Roraima, *McConnell & Quelch*, 632. Also collected on Roraima by *Appun*, 1112.—Kanuku Mountains.

DIODIA HYSSOPIFOLIA, Cham. & Schlecht. in Linnæa, iii. (1828), p. 350. Kotinga Valley, *McConnell & Quelch*, 190.

COMPOSITÆ.

Vernonia acuta, N. E. Brown, sp. n. Rami tomentosi. Folia alterna, brevissime petiolata, lanceolata, acutissima vel subpungentia, basi acuta, supra glabra, subtus tenuiter et appresse pubescentia, glanduloso-punctata; petiolus tomentosus. Capitula in axillis aggregata, sessilia, sub-10-flora. Involucri squamæ 5–6 seriatæ, imbricatæ, lanceolatæ, acuminatæ, pungentes, subtomentosæ, exteriores gradatim minores. Achænia appresse pubescentia. Pappus biserialis, squamis exterioribus linearibus acutis quam setis interioribus multo brevioribus.

Branchlets densely tomentose. Leaves alternate, spreading; petiole 1–2 lin. long, tomentose; blade $1\frac{1}{4}$–2 in. long, $\frac{1}{4}$–$\frac{1}{2}$ in. broad, lanceolate, very acute and subpungent at the apex, acute at the base, entire, with revolute margins, rather rigid, glabrous above, except the midrib, which is pubescent, thinly covered with short adpressed hairs and gland-dotted beneath, with the veins and reticulated veinlets impressed above, prominent beneath. Heads in clusters of 3 or 4, sessile in the axils of the leaves at the ends of the branchlets, about $\frac{1}{4}$ in. diam., and about 10-flowered. Involucre-scales in 5–6 series, adpressed, lanceolate, acuminate, pungent-pointed, adpressed-pubescent or subtomentose, the innermost about 3 lin. long, $\frac{1}{2}$–$\frac{2}{3}$ lin. broad, the others gradually smaller. Corolla $\frac{1}{4}$ in. long, 5-lobed, with the linear acute lobes of equal length with the tube, glabrous. Style-branches only about $\frac{1}{2}$ lin. longer than the stamens. Achenes rather more than 1 lin. long, adpressed-pubescent. Pappus in two series, white; the outer of numerous linear acute scales, the inner of numerous bristles, slightly scabrous, much longer than the outer series.

Kotinga Valley, *McConnell & Quelch*, 192.

Eupatorium ivæfolium, Linn. Syst. ed. 10, p. 1205, var. gracillimum, Baker, in Mart. Fl. Bras. vi. pt. II. p. 290.

Ireng Valley, *McConnell & Quelch*, 242.

Eupatorium subobtusum, DC. Prod. v. p. 161.

Ireng Valley, *McConnell & Quelch*, 211, 304.

Eupatorium roraimense, N. E. Brown, sp. n. Herbacea, ramis breviter pubescentibus. Folia opposita, petiolata, ovato-lanceolata, acuminata, glabra, crenato-dentata, petiolo pubescente. Capitula corymbosa, circa 20-flora. Involucri squamæ lineares, acutæ, glabræ. Corollæ 5-dentata, glabra, tubo supra medium ampliato, campanulato, dentibus ovatis, acutis. Achænia 5-angulata, angulis scaberulis. Pappi setæ scaberulæ, roseo-purpureæ.

Stems herbaceous, with a very fine spreading pubescence. Leaves opposite; petiole 4–6 lin. long, pubescent; blade $1\frac{1}{4}$–$2\frac{1}{2}$ in. long, $\frac{1}{2}$–1 in. broad, ovate-lanceolate, acuminate, crenately toothed, with teeth 1–2 lin. broad, glabrous on both sides, rather thin and submembranous in texture in the dried state. Corymbs terminal, compact, 2–$2\frac{3}{4}$ in. diam., its branches $\frac{1}{4}$–1 in. long, and, together with the slender $1\frac{1}{2}$–3 lin. long pedicels, pubescent like the stem. Bracteoles almost filiform. Heads about $2\frac{1}{2}$ lin. diam., about 20-flowered. Involucre-scales 2-seriate, 2–$2\frac{1}{4}$ lin. long, linear, acute, nearly or quite glabrous. Corolla glabrous, the tube 1 lin. long, slender below, dilated into a campanulate cup above the middle, with 5 ovate acute teeth ½ lin. long. Achenes 1 lin. long, 5-angled, slightly scabrous along the angles, blackish. Pappus-bristles slightly scabrous, rosy-purple.

Summit of Mount Roraima, *McConnell & Quelch*, 640.

This somewhat resembles *Eupatorium Pentlandianum*, DC. (*Mandon*, 259), but the corolla, pappus, and achenes are all much shorter, the corolla is very different in form, the involucre-scales are longer and narrower, and the leaves are less sharply toothed.

EUPATORIUM FUSCUM, N. E. Brown, sp. n. Rami validi, cum petiolis et corymbis nigrescente-tomentosi. Folia breviter petiolata, late ovata, obtusa, basi rotundata vel subcordata, irregulariter et obtuse dentata, subcoriacea, supra glabra, glanduloso-punctata, subtus fusco-pubescentia. Corymbi compacti. Capitula 15–16-flora. Involucri squamæ biseriatæ, interiores lineari-oblongæ acutæ, exteriores minores. Corolla subcylindrica, breviter 5-dentata, tubo glabro, dentibus dorso minute papillatis. Pappi setæ scabridæ, plus minusve flexuosæ, subfulvescentes.

Flowering branches stout, 2–2½ lin. thick, densely covered with a short blackish tomentum. Leaves opposite, rather crowded, 4–9 lin. distant; petiole 2–3 lin. long, stout, with a blackish tomentum, which spreads along the veins of the leaf; blade 1–1¾ in. long, 10 lin. to 1¾ in. broad, broadly ovate, obtuse, rounded or subcordate, very shortly and irregularly dentate, with subobtuse teeth, or nearly entire, somewhat coriaceous, glabrous (except along the veins,) and densely gland-dotted above, with a brownish or fuscous pubescence beneath; primary lateral veins 4–5 on each side of the midrib, 2–3 of them arising close to the base, the others at or above the middle, prominent beneath. Corymbs terminal, 1½–2½ in. diam., compact, with short branches, clothed with the blackish tomentum as are also the pedicels and involucres. Heads about ⅓ in. diam., 15–16-flowered. Involucral-scales in two series; the inner about 2 lin. long, ½ lin. broad, linear-oblong acute; the outer a little shorter, narrower and tapering from the base to an acute point. Corolla 2 lin. long, tubular, subcylindric, 5-toothed, glabrous, with some minute papillæ on the back of the ⅓ lin. long, acute teeth. Ovary pubescent in the upper part with short fuscous subglandular hairs. Pappus-bristles numerous, scabrid, more or less flexuose, dull tawny. Ripe achenes not seen.

Summit of Mount Roraima, 8600 ft., *McConnell & Quelch*, 648.

A very distinct species, which would appear to be best placed near *E. nummularia*, Hook. & Arn.

BACCHARIS VITIS-IDÆA, Oliver, in Trans. Linn. Soc. Ser. II. Bot. ii. (1887), p. 277, t. 43. f. A.

Upper slopes and summit of Mount Roraima, *McConnell & Quelch*, 27, 91, 650.—Endemic.

HETEROTHALAMUS DENSUS, N. E. Brown, sp. n. (Plate 7, figs. 1–7.) Planta nana, perennis, dioica, dense foliosa. Folia patentia, lanceolata, acuta vel obtusa, basi in petiolum attenuata, integra, coriacea, nitida. Capitula sessilia, 2–4-na ad apices ramorum conferta vel solitaria, discoidea. Flores hermaphroditi steriles, corollæ tubo anguste infundifuliformi, lobis 5 linearibus acutis patentibus. Florum fœmininorum corolla angustissime tubulosa, truncata, vel oblique truncata, minutissime denticulata, stylo multo brevior.

A dwarf diœcious perennial with erect woody stems, apparently about 3–5 in. high, rooting at the base, sparingly branched in the upper part, densely leafy to the top, quite glabrous in all parts. Leaves densely crowded, spreading, ⅓–⅔ in. long (including the petiole), 1–2 lin. broad, lanceolate, acute or obtuse, tapering at the base into a linear petiole, entire, coriaceous, shining above, wrinkled from shrinkage in drying, veinless. Heads subunisexual, solitary or 2–4 together, sessile at the apex of the branches, and surrounded, but not overtopped by the leaves, about 2½ lin. diam., discoid, many-flowered. Involucre campanulate, a little shorter than the florets, its scales in 2–3 series, subequal, about 1½ lin. long, ⅔ lin. broad, oblong or lanceolate, obtuse or acute, ciliate. Receptacle naked in the sterile heads, but with several linear or linear-lanceolate acute scales in the female heads, scattered among, and about as long as, the florets. Florets of the sterile heads structurally hermaphrodite, but with barren ovaries; corolla with a tube 1 lin. long, gradually widening at the mouth, and 5 linear, acute, spreading lobes ½ lin. long, glabrous. Florets of the female heads with a very slender tubular corolla, truncate or oblique and very minutely 5-toothed at the apex, much shorter than the shortly bifid style, glabrous. Ovary glabrous. Pappus-bristles numerous and alike in both kinds of flowers, equalling the style in the female florets, slightly scabrid, whitish.

Summit of Mount Roraima, 8600 ft., *McConnell & Quelch*, 631.

Pterocaulon virgatum, DC. Prod. v. p. 454, var.

Kotinga Valley, *McConnell & Quelch*, 159. Savannahs generally, *McConnell & Quelch*, 306.

Stifftia condensata, Baker, in Mart. Fl. Bras. vi. pt. III. p. 351; im Thurn & Oliver, in Trans. Linn. Soc. Ser. II. ii. (1887), pp. 254, 278.

Summit of Mount Roraima, *McConnell & Quelch*, 87, 651.—Endemic.

Stifftia Connellii, N. E. Brown, sp. n. (Plate 8.) Rami 2–3 lin. crassi, tomento compacto cinereo dense obtecti. Folia petiolata, coriacea, oblonga vel oblongo-obovata, obtusa, basi cuneato-rotundata, supra glabra, subtus tomento deciduo vestita. Capitula solitaria, magna. Involucri subinfundibuliformis bracteæ multiseriatæ; interiores ligulatæ obtusæ; exteriores gradatim minores, ovatæ, obtusæ, subtomentosæ. Receptaculum bracteis linearibus minute dentato-ciliatis paucis onustum. Corolla infra medium 5-loba, glabra, lobis linearibus acutis spiraliter revolutis. Stylus longe exsertus, apice minute bifidus.

Branches woody, 2–3 lin. thick, covered with a dense, felt-like, greyish tomentum. Leaves alternate, petiolate, coriaceous; petiole ¼–¾ in. long, tomentose; blade 3½–5½ in. long, 1½–2½ in. broad, oblong or obovate-oblong, obtuse, somewhat cuneately rounded at the base, entire, glabrous above, clothed with a deciduous tomentum beneath, which falls away in patches; midrib and veins about equally prominent on both sides. Heads solitary, terminal, about 2½ in. long and 2 in. diam. Involucre somewhat funnel-shaped, shorter than the florets, with imbricating bracts in 10 or 12 series, the innermost about 1⅓ in. long, 1¾–3½ lin. broad, strap-shaped to lanceolate-oblong, obtuse, the outer gradually smaller, ovate, obtuse, tomentose on the back. Receptacle with a few deciduous bracts, scattered among the florets, about 1¼ in. long, linear, obtuse, sparsely and minutely denticulate-ciliate. Corolla glabrous, with a tube about ½ in. long, slightly enlarging upwards, and spirally revolute linear-acute lobes, about 8 lin. long, ½–⅔ lin. broad. Anthers about 7 lin. long, with the tails connate in pairs. Ovary ¼ in. long, compressed, glabrous. Style much exserted, minutely bifid at the apex. Pappus-bristles copious, unequal, the longest about 10 lin. long, minutely adpressed pubescent, dull straw-coloured, or pale tawny.

Summit of Mount Roraima, 8600 ft., *McConnell & Quelch*, 661.

A very distinct species, readily distinguished by its large heads, and the very long exserted styles. It appears to be a connecting link between *Stifftia* and *Wunderlichia*. The presence of bracts upon the receptacle and the minutely bifid stigma, technically place it in the genus *Wunderlichia*, Riedel, but the plant has a different appearance, and the receptacular bracts are not persistent and not of the same character or scarious texture as those of *Wunderlichia*. In all probability when more species are discovered it will be found that the two genera will have to be united.

QUELCHIA, N. E. Brown, gen. nov.

Capitula 1-flora in glomerulum vel cymam densam aggregata. Involucrum conico-tubulosum, bracteis imbricatis interioribus elongatis, exterioribus gradatim brevioribus ovatis. Receptaculum parvum, nudum. Corolla regularis, profunde 5-loba, tubo brevissimo, lobis linearibus. Antheræ basi caudato-sagittatæ, caudis retrorsim subbarbatis. Styli rami breves, erecti, truncati. Achænia subteretia, leviter costata. Pappi setæ copiosæ.—Frutex, foliis alternis integris coriaceis. Capitulorum glomeruli pedunculati.

QUELCHIA CONFERTA, N. E. Brown. (Plate 7, figs. 8–14.) Rami apice tomentosi. Folia petiolata, obovata vel oblongo-oblanceolata, obtusa vel apiculata basi cuneato-acuta, primum subtomentosa, demum glabrata. Glomeruli vel corymbi ¾–1 poll. diam. Pedunculi tomentosi. Capitula sessilia, 1-flora, conferta. Involucri bracteæ interiores anguste lanceolatæ, obtusæ, glabræ; exteriores ovatæ, dorso tomentosæ. Corolla glabra. Achænia 2½ lin. longa, glabra. Pappi setæ 3–4 lin. longæ vix vel leviter scabridæ.

Apparently a shrub, densely tomentose on the youngest parts of the shoots. Leaves alternate, coriaceous, petiolate; petiole 2–6 lin. long, tomentose in the young state becoming glabrous; blade 1–2½ in. long, 5–10 lin. broad, obovate or oblong-oblanceolate, obtuse or more or less apiculate, cuneate-acute at the base, entire, at first with a thin tomentum on both sides, which soon disappears and the leaf becomes glabrous; midrib impressed and pubescent above, very prominent beneath, veins reticulated, impressed above, scarcely prominent beneath. Corymbs pedunculate, small, hemispherical or subglobose, very densely many-headed, ¾–1 in. diam. Peduncles ½–1½ in. long, tomentose, bearing a few small leaf-like bracts at the base of the very short branches of the corymb. Heads sessile, densely crowded, about 4 lin. long, 1-flowered. Involucre cylindric-conical, with 12–16 spirally imbricating scales, the innermost about $3\frac{1}{2}$ lin. long, $\frac{1}{2}$–1 lin. broad, narrowly lanceolate obtuse, glabrous, the outer gradually shorter and more and more ovate, and more or less tomentose on the back. Floret not exceeding the involucre (?), hermaphrodite. Corolla regular, very deeply 5-lobed, glabrous, the lobes about $2\frac{1}{2}$ lin. long, linear, acute, incurved at the apex. Stamens with free filaments and syngenesious anthers, which are produced at the base into long, slightly barbed tails. Achenes $2\frac{1}{2}$ lin. long, subterete, slightly grooved, glabrous. Pappus-bristles copious, 3–4 lin. long, nearly smooth or very slightly scabrid, pale tawny-white.

Summit of Mount Roraima, 8600 ft., *McConnell & Quelch*, 652.

This plant appears to be nearly allied to the genus *Moquinia*, DC., but differs in habit and in its 1-flowered, densely-crowded heads. I am somewhat doubtful as to the exsertion of the floret from the involucre during flowering, as I have only seen the corollas in the bud state; when in fruit the achene is as long as the involucre and the pappus is entirely exserted.

CAMPANULACEÆ.

Centropogon surinamensis, Presl, Prod. Monog. Lobel. p. 48; im Thurn & Oliver, in Trans. Linn. Soc. Ser. II. Bot. ii. (1887), pp. 261, 278.

Kotinga Valley, *McConnell & Quelch*, 156.—Widely dispersed throughout Tropical America except on the west of the Andes.

VACCINIACEÆ.

Psammisia coriacea, N. E. Brown, sp. n. Frutex glaber. Folia breviter petiolata, obovata, oblonga vel orbiculata, crasse coriacea, integra, infra reticulato-venosa. Flores in axillis aggregati, penduli. Pedicelli recurvi, bibracteolati. Calyx cum pedicello articulatus, limbo breviter 4–5-dentato. Corolla $\frac{1}{2}$ poll. longa, tubulosa, ore angustata, breviter 4–5-loba, lobis erectis lineari-oblongis obtusis. Stamina inclusa, biseriata, libera, glabra, antheris longe bitubulosis. Ovarium subglobosum. Stylus corolla subæquilongus, nec exsertus.

A shrub with a greyish-brown bark. Leaves shortly petiolate, thick and rigidly coriaceous, glabrous; petiole 1–2 lin. long, stout; blade $\frac{3}{4}$–$1\frac{1}{2}$ in. long, $\frac{1}{2}$–$1\frac{1}{2}$ in. broad, varying from obovate to orbicular, obtuse, entire, reticulately veined beneath. Flowers in clusters of 3–9 in the axils of the leaves, pedicellate, drooping. Pedicels about 4 lin. long, curved, bibracteolate at the middle or below, glabrous. Bracteoles opposite or subopposite, $\frac{1}{4}$–$\frac{1}{3}$ lin. long, broadly ovate, obtuse or subapiculate, very minutely ciliate. Calyx about $2\frac{1}{4}$ lin. long, glabrous, jointed to the pedicel, truncate at the base, with a subglobose tube and a cup-shaped shortly 4–5-toothed limb, the teeth very much broader than long, acute or apiculate. Corolla $\frac{1}{2}$ in. long, about 2 lin. diam., tubular, narrowed at the mouth, 4–5-lobed, glabrous inside and outside; lobes 1 lin. long, erect, linear-oblong, obtuse. Stamens 8–10, included, biseriate, glabrous; the shorter filaments $1\frac{1}{3}$ lin. long, the longer $1\frac{3}{4}$ lin. long; anthers $\frac{1}{4}$ in. long, with the cells passing into two long tubes about 3 times as long as the united part, opening by long oblique slits Ovary subglobose, 4–5-celled; style 5½–6 lin. long, not exserted, filiform, glabrous; stigma small, discoid. Ovules numerous in each cell. Berry globose, many-seeded; seeds about ⅔ lin. long, variable in form, with a pale brown reticulated testa.

Summit of Mount Roraima, 8600 ft., *McConnell & Quelch*, 662.

VACCINIUM RORAIMENSE, N. E. Brown, sp. n. Fruticulus, ramis patente pubescentibus foliosis. Folia parva, breviter petiolata, rigide coriacea, lanceolata obovata vel elliptica, obtusa vel rare acuta, crenato-dentata vel integra, glabra, marginibus subtus incrassata. Racemi breves, terminales, bracteati. Pedicelli bracteolati, pubescentes. Bracteolæ lanceolatæ, acutæ, tenuiter glanduloso-ciliatæ. Calyx glaber, lobis deltoideo-ovatis acutis. Corolla 2¾ lin. longa, urceolata, breviter 5-loba. Stamina 10, inclusa, filamentis a basi attenuatis ciliatis, antheris acutis nec aristatis. Ovarium obconicum, 5-loculare, glabrum, loculis 2–3-ovulatis.—*Vaccinium, an V. floribundum*, H. B. & K.?, Oliver, in Trans. Linn. Soc. Ser. II. Bot. ii. (1887) p. 278.

A small branching shrub, probably of dwarf habit. Branches rather slender, very leafy, pubescent with short spreading hairs. Leaves small, petiolate, thick, rigidly coriaceous, glabrous; petiole ½–1¼ lin. long; blade 3½–7 lin. long, 2–5½ lin. broad, varying from lanceolate to elliptic, obtuse or bluntly pointed, rarely acute, crenately toothed or entire, with the margins much thickened beneath, and the veins usually inconspicuous above, more or less evident beneath. Flowers in short terminal bracteate racemes, or aggregated at the apex of the branches. Pedicels 1½–3, rarely 4–5 lin. long, pubescent, bracteolate. Bracts and bracteoles similar, 1–1½ lin. long, lanceolate, acute, or occasionally the bracts are larger and resemble very small leaves, glabrous, more or less gland-ciliate. Calyx jointed to the pedicel, with a 5-lobed limb, glabrous; lobes 1 lin. long, deltoid-ovate, acute. Corolla 2¾ lin. long, urceolate, 5-lobed, glabrous; lobes about ¾ lin. long, broadly ovate, obtuse. Stamens 10, included; filaments 1 lin. long, tapering upwards from a broad base, ciliate; anthers acute but not aristate. Ovary obconical, surmounted by a thick ring-like disk, 5-celled, with 2–3 ovules in each cell, glabrous; style about 1½ lin. long; stigma dilated cushion-like.

Summit of Mount Roraima, 8600 ft., *im Thurn*, 329, 333; *McConnell & Quelch*, 79, 194, 642.

Allied to *V. polystachyum*, Benth., but very different in foliage.

Besides the above, there is a specimen belonging to this family which is too imperfect for identification; it was collected in the Kotinga Valley, *McConnell & Quelch*, 187.

ERICACEÆ.

PERNETTYA MARGINATA, N. E. Brown, sp. n. Frutex foliosus, ramis gracilibus plus minus hirtis. Folia breviter petiolata, coriacea, ovata vel elliptica, acuta vel subacuta, basi rotundata, supra glabra, nitida, infra sæpe parce setulosa, marginibus infra incrassatis setuloso-denticulatis. Flores axillares, solitares. Pedicelli bracteolati, pubescentes.

Bracteolæ ovatæ, glanduloso-denticulatæ. Calyx glaber, lobis ovatis acutis minute ciliatis. Corolla $3\frac{1}{2}$ lin. longa, urceolata, breviter 5-loba, lobis recurvis. Stamina inclusa, filamentis basi dilatis ciliatis, antheris apicibus 4-aristatis. Bacca globosa, $\frac{1}{4}$ poll. diam.—*P. sp. aff. parvifoliæ*, Benth., Oliver, in Trans. Linn. Soc. Ser. II. Bot. ii. p. 278.

A shrub with very leafy slender branches, which are more or less covered with scattered spreading hairs, but are scarcely hispid, and occasionally nearly glabrous. Leaves small, rather crowded, petiolate, rigidly coriaceous; petiole about 1 lin. long; blade 5–8 lin. long, $3\frac{1}{2}$–$4\frac{1}{2}$ lin. broad, ovate or elliptic, acute or subacute, rounded at the base, thickened and slightly recurved along the denticulate margins beneath, the teeth tipped with a minute bristle, usually with a few scattered bristle-like hairs beneath, otherwise glabrous, shining and rugose from depressions (caused by shrinkage in drying?) between the veins above. Flowers axillary, solitary. Pedicels 2–5 lin. long, more or less pubescent, bracteolate. Bracteoles 5 or 6, about 1 lin. long, ovate, acute, gland-toothed, the lowermost crowded. Calyx 5-lobed nearly to the base, not enlarging in the fruiting stage; lobes $1\frac{1}{2}$ lin. long, $\frac{3}{4}$–1 lin. broad, ovate, acute, minutely ciliate, otherwise glabrous. Corolla $3\frac{1}{2}$ lin. long, urceolate, glabrous, with 5 ovate obtuse recurved lobes $\frac{3}{4}$–1 lin. long. Stamens shorter than the corolla, 2 lin. long; filaments ovate-lanceolate, acuminate, ciliate with rather long hairs; anthers tipped with 4 bristles about $\frac{1}{3}$ as long as the cells. Ovary subglobose, glabrous; style $1\frac{1}{2}$ lin. long, glabrous; stigma dilated, discoid. Berry globose, about $\frac{1}{4}$ in. in diam.

Summit of Mount Roraima, 8600 ft., *McConnell & Quelch*, 637; *im Thurn*, 333 A.

Allied to *Pernettya rigida*, DC., but among other characters the more thickened margin of the leaves and more numerous bracteoles serve readily to distinguish it.

GAULTHERIA SETULOSA, N. E. Brown, sp. n. Frutex setulis glanduliferis ubique vestitus. Folia brevissime petiolata, late cordato-ovata vel suborbicularia, coriacea, integra, utrinque setuloso-scabrida, ciliata. Racemi solitarii vel 2–3-ni ad apices ramorum, bracteati. Calycis lobi deltoideo-ovati, acuminati. Corolla urceolata, breviter 5-loba, intra glabra. Stamina inclusa, filamentis linearibus ciliatis, antheris obtusis muticis. Ovarium depressum, 5-lobum, pubescens.—*Gaultheria aff. G. vestitæ*, Benth., Oliver in Trans. Linn. Soc. Ser. II. Bot. ii. (1887) p. 278.

A shrub, more or less clothed with long setæ or gland-tipped hairs on the branches, leaves, and inflorescence. Leaves very shortly petiolate, $\frac{3}{4}$–$1\frac{3}{4}$ in. long, $\frac{2}{3}$–$1\frac{1}{2}$ in. broad, ovate or suborbicular, obtuse or subacute, cordate at the base, entire, rigidly coriaceous, more or less setose or scabrid on both sides, ciliate, with the veins much reticulated and prominent beneath. Racemes solitary or 2–3 together at the apex of the branches, erect, bracteate, 1–4 in. long, 7–15-flowered, rather lax, puberulous and more or less densely covered with gland-tipped bristles on the axis, bracts, pedicels, calyx, and corolla. Bracts $\frac{1}{4}$–$\frac{1}{2}$ in. long, 2–$3\frac{1}{2}$ lin. broad, elliptic subacute, concave, spreading, persistent. Pedicels 3–8 lin. long, ascending or spreading. Calyx 2–$2\frac{1}{2}$ lin. long, 5-lobed to $\frac{3}{4}$ the way down, the lobes $1\frac{1}{2}$–2 lin. long, deltoid-ovate, acuminate. Corolla $3\frac{1}{2}$–4 lin. long, $2\frac{1}{2}$ lin. diam., urceolate, with 5 recurved, ovate, obtuse lobes $\frac{3}{4}$ lin. long, glabrous inside. Stamens 10, included, $\frac{2}{3}$ as long as the corolla; filaments linear, ciliate; anthers $\frac{3}{4}$ lin.

long, oblong, obtuse, shortly bifid at the apex, but not in the least produced into awns or tubes, opening by longitudinal slits nearly to the base. Ovary depressed, 5-lobed, pubescent; style included, rather stout, glabrous; stigma simple, not enlarged. Capsule depressed, 5-angled, pubescent.

Summit of Mount Roraima, 8600 ft., *im Thurn*, 332; *McConnell & Quelch*, 104, 647.

Allied to *Gaultheria cordifolia*, H. B. & K., and *G. vestita*, Benth., but differing from both in the scabrid upper surface of the leaves, the stouter gland-tipped setæ which clothe it, and by the obtuse, not aristate anthers.

LEDOTHAMNUS SESSILIFLORUS, N. E. Brown, sp. n. Fruticulus nanus, ericoideus. Folia verticillata, 3-na vel 4-na ad nodos posita, imbricata, brevissime petiolata, linearia vel lineari-lanceolata, acuta, minute puberula. Flores solitarii, terminales, sessiles. Sepala 7 vel 6, anguste lanceolata, acuta, puberula vel subglabra, ciliata. Petala 7 vel 6, oblonga obtusa, glabra. Stamina 7 vel 6, filamentis quam antheris multo longioribus. Discus nullus. Ovarium subglobosum vel ovoideum, granulosum, 5–8-loculare; stylus crassus; stigma subinfundibuliforme, minute 5–8-lobulatum.

A dwarf shrublet 4–8 in. high. Stems erect, simple or branched, densely leafy to the apex, at first minutely puberulous, becoming glabrous, and rough from the persistent scars of the fallen leaves. Leaves resembling those of an *Erica*, in densely crowded whorls of 3–4, ascending, imbricating, 1½–2½ lin. long, ½–⅔ lin. broad, linear or narrowly linear-lanceolate, acute, narrowed at the base into a very short petiole, thick, flat on the face, grooved down the back, minutely puberulous, ciliate or entire. Flowers terminal, solitary, ¾–1¼ in. diam., sessile, surrounded by a few bracts that are intermediate in character between the sepals and leaves. Sepals 7 or occasionally 6, spreading, 3–4½ lin. long, ⅔–¾ lin. broad, narrowly lanceolate, acute, minutely puberulous or subglabrous, ciliate. Petals usually 7, very spreading, bright crimson, 5–7 lin. long, 2–3 lin. broad, oblong, obtuse, cuneately narrowed at the base, entire, glabrous. Stamens 7 or 6, shorter than the petals, glabrous; filaments 3½–4½ lin. long, gradually dilated towards the base; anthers 1½ lin. long, oblong, obtuse. Ovary subglobose or ovoid, granulate-rugose, 5–8-celled, with a stout style 1¼–1½ lin. long, slightly dilated at the apex into a funnel-shaped minutely 5–8-lobed stigma. Capsule sessile, 2–2½ lin. diam., 5–8-valved, granulate.

Summit of Mount Roraima, 8600 ft., *McConnell & Quelch*, 643.

Var. GLABER, N. E. Brown, var. n. Folia et sepala glabra, ciliata.

Leaves and sepals glabrous, ciliate.

L. guyanensis, Meissn., var. *minor*, Oliver, in Trans. Linn. Soc. Ser. II. Bot. ii. (1887), p. 278, t. 44. f. A.

Mount Roraima, on the upper part of the Ledge and on the summit, *Im Thurn*, 308; *McConnell & Quelch*, 99.

This plant is very distinct from *L. guyanensis*, Meissn., with which it has been associated by Oliver, differing not only by its smaller size and smaller leaves, but more especially by its sessile flowers and the long filaments of the stamens. In *L. guyanensis* the flowers have pedicels ⅓–⅔ in. long covered with gland-tipped hairs, and the filaments of the stamens are only about 1 lin. long and shorter than the anthers.

BEFARIA GUIANENSIS, Klotzsch, in R. Schomb. Reisen in Brit.-Guiana, iii. p. 1088; Oliver, in Trans. Linn. Soc. Ser. II. Bot. ii. (1887), p. 278; Appun, Unter den Tropen, ii. pp. 232, 287, 292.

Upper slopes and Ledge of Mount Roraima, *McConnell & Quelch*, 40.—Endemic.

BEFARIA IMTHURNII, N. E. Brown, sp. n. Fruticulus nanus, ramis pilis glanduliferis vel setulis vestitus. Folia conferta, breviter petiolata, coriacea, elliptico-oblonga vel elliptico-lanceolata, utrinque obtusa vel acuta, supra glabra, subtus glauca et glabra vel costa plus minus setulosa, marginibus integris vel glanduloso-scabridis vel ciliatis. Racemi subumbelliformes, densi. Pedicelli subhispidi. Calyx campanulatus, 7–8-lobus, lobis biseriatis late ovatis obtusis. Petala 6–8, oblonga, obtusa. Stamina 12–16, petalis subæquilonga, basi pilosa.—*Befaria aff. B. resinosæ*, Mutis; Oliver in Trans. Linn. Soc. Ser. II. Bot. ii. (1887), p. 278.

A dwarf shrublet, with the branchlets densely covered with spreading simple or gland-tipped hairs, very leafy. Leaves crowded, very shortly petiolate, coriaceous; petiole $\frac{1}{2}$–1 lin. long; blade $\frac{1}{2}$–1 in. long, $\frac{1}{4}$–$\frac{1}{2}$ in. broad, elliptic-oblong or elliptic-lanceolate, about equally acute or obtuse at each end, with slightly revolute margins, which are either quite entire, minutely gland-scabrid, or ciliate with short gland-tipped bristles or longer simple hairs, glabrous and smooth above, glaucous and either quite glabrous or with some simple or gland-tipped bristles scattered along the midrib beneath. Flowers several, crowded into a short terminal umbel-like raceme or cluster, each flower being solitary in the axil of one of the uppermost leaves. Pedicels 3–7 lin. long, more or less densely covered with stiff spreading hairs. Calyx about 2 lin. long, campanulate, 7–8-lobed to about the middle, with the lobes in two series, broadly ovate, obtuse, glabrous, minutely ciliate. Corolla glabrous, pink; petals 6–8, slightly spreading, 8–9 lin. long, 3 lin. broad, oblong, obtuse, cuneate at the base. Stamens 12–16, about as long as the petals; filaments filiform, slightly thickened and hairy at the base; anthers 1 lin. long, cuneately oblong, obtuse. Ovary depressed, lobulate, glabrous, with a glabrous style 6–8 lin. long, elongating to 1–1$\frac{1}{4}$ in. long in fruit, and a capitate slightly lobed stigma. Capsule about $\frac{1}{4}$ in. diam., woody, 6 (or more ?)-valved.

Summit of Mount Roraima, 8600 ft., *im Thurn*, 310; *McConnell & Quelch*, 94, 646.

Allied to *B. guianensis*, Klotzsch (*Schomburgk*, 1041), from which it differs in its less elongated, glabrous leaves. In *B. guianensis* the leaves are 1–1$\frac{1}{2}$ in. long, and their upper surface is thinly covered with short gland-tipped bristles, tubercular at the base, becoming more or less scabrid after the bristles have fallen or have been rubbed off; on the under side they are more or less densely covered all over with fine gland-tipped hairs, with longer hairs on the midrib, and they appear to be less glaucous than in *B. Imthurnii.*

MYRSINACEÆ.

ARDISIA QUELCHII, N. E. Brown, sp. n. Frutex dioicus, glaber, ramis crassis. Folia alterna, petiolata, coriacea, obovata vel subelliptica, obtusa vel rare subacuta, integra, subtus minutissime rubro-glandulosa. Paniculæ axillares, anguste oblongæ vel pyramidales, minutissime rubro-glandulosæ, floribus parvis ad apices ramorum confertis. Calyx profunde 4-lobus, glanduloso-punctatus, lobis oblongis obtusis. Corolla profunde 4-loba, glanduloso-punctata, lobis oblongis obtusis patentibus. Stamina 4, corollæ lobis breviora et prope basin inserta, filamentis quam antheris paulo brevioribus.

A diœcious shrub, probably of dwarf habit, glabrous in all parts, with branches ¼ in. thick, terete. Leaves chiefly near the apex of the stem, alternate, petiolate, coriaceous; petiole 2–4 lin. long, rather stout; blade 1½–2½ in. long, 10–16 lin. broad, obovate or occasionally subelliptic, obtuse, rarely subacute, with revolute margins, entire, more or less densely covered with very minute red glands beneath. Panicles axillary, near the summits of the branches, narrowly oblong or pyramidal, 1–3¼ in. long, ⅓–1¼ in. broad, covered with minute red glands, with the flowers crowded at the ends of the short, rather distant, simple branches. Bracts ½–1 lin. long, oblong, obtuse, dotted with rather large dark-coloured glands. Calyx 4-lobed nearly to the base; lobes ½–⅔ lin. long, oblong, obtuse, conspicuously gland-dotted. Corolla about 2 lin. diam., 4-lobed nearly to the base; lobes ¾–1 lin. long, rather more than ½ lin. broad, conspicuously gland-dotted. Stamens 4, shorter than and inserted towards the base of the corolla-lobes, with stout filaments rather shorter than the oblong, ⅓ lin. long anthers. Ovary rudimentary, minute, subulate, or none. Female flowers not seen.

Summit of Mount Roraima, 8600 ft., *McConnell & Quelch*, 665.

A very distinct species, unlike any other.

APOCYNACEÆ.

Mandevilla glabra, N. E. Brown, sp. n. Caules volubiles, glabrescentes. Folia parva, distantia, petiolata, coriacea, lanceolata, acuminata, apice obtusa, glabra. Racemi brevissimi, pauciflori, axillares, glabri. Pedunculi et pedicelli brevissimi. Sepala parva, ovata, acuta, glabra. Corolla infundibularis, 2¼ poll. longa, extra glabra, intra ad insertionem staminum pilis deflexis dense barbata, lobis dolabriformibus. Stamina inclusa, filamentis oblongis apice barbatis, antheris acutis, basi cordatis obtusis.

Stem twining, about 1 lin. thick, glabrous or with a very few short scattered hairs, brown. Leaves opposite, distant, petiolate, coriaceous, glabrous; petiole 2–3 lin long; blade ¾–1 in. long, 3½–4 lin. broad, lanceolate, acuminate, obtuse at the point, entire, with the midrib impressed above, prominent beneath, and having 5 or 6 small tubercles or glands scattered along it on the upper side, the lateral veins spreading, slightly impressed on both sides in the dried state, not very conspicuous. Racemes axillary, from one axil, very short, about 3-flowered in the specimen seen; glabrous. Peduncle about 1 lin. long, stout. Pedicels alternate, 1–1½ lin. long, stout. Sepals 1 lin. long, ⅔–¾ lin. broad, ovate, acute, glabrous, each with a very short, transversely oblong, denticulate scale at its base inside. Corolla about 2¼ in. long, funnel-shaped; tube curved, cylindrical and about 1½ lin. diam. in the lower half, much enlarged and subcampanulate in the upper half, glabrous outside and inside, except 5 broad lines that are densely bearded with deflexed white hairs at the insertion of the stamens within; lobes about $\frac{3}{4}$ in. long, hatchet-shaped, one side being dilated into a large square membranous obtuse lobe. Stamens inserted at the top of the narrow part of the tube included; filaments about 1 lin. long and nearly as broad, flat, oblong, slightly bearded near the apex on the inner face; anthers $3\frac{1}{3}$ lin. long, linear-oblong, acute, shortly cordate at the base, connate, adnate to the stigma. Disk shortly lobed. Ovary glabrous; style about 14 lin. long, slender, glabrous; stigma conical, 5-winged.

Upper slopes of Mount Roraima, *McConnell & Quelch*, 16.

Mandevilla linearis, N. E. Brown, sp. n. Caules volubiles, graciles, puberuli. Folia breviter petiolata, linearia, acuta, supra glabra, subtus tomentosa, marginibus fere vel usque ad costam revolutis. Racemi breves, pauciflori, minute puberuli. Bracteæ parvæ, acuminatæ. Pedicelli brevissimi. Sepala parva, deltoidea, acuminata. Corolla infundibularis, $2\frac{1}{4}$ poll. longa, recta, extra glabra, intra ad mediam dense barbata. Stamina inclusa, filamentis ellipticis glabris, antheris subacutis basi breviter cordatis vel emarginatis.

Stem twining, slender, puberulous. Leaves opposite, $\frac{3}{4}$–$2\frac{1}{2}$ in. distant, petiolate, thinly coriaceous; petiole 1–$1\frac{1}{2}$ lin. long, rather slender, puberulous; blade $1\frac{1}{2}$–$2\frac{1}{4}$ in. long, linear, acute, obtuse at the base, with the margins revolute nearly or quite to the midrib, glabrous and shining, with an impressed midrib above, tomentose, with a prominent midrib beneath, the tomentum usually hidden by the revolute margins. Racemes short, $\frac{1}{2}$–$\frac{3}{4}$ in. long, more than half of which is peduncle, 3–4-flowered, very minutely puberulous. Bracts about $\frac{3}{4}$ lin. long, ovate, acuminate. Pedicels alternate, about 1 lin. long, rather stout. Calyx-lobes about $1\frac{1}{4}$ lin. long, deltoid, acuminate, subglabrous or very minutely puberulous, each with a small ovate scale at the base inside. Corolla about $2\frac{1}{4}$ in. long, funnel-shaped, straight, 5-lobed, glabrous outside, the middle part of the tube inside densely covered with deflexed white hairs; tube cylindric and about $1\frac{1}{2}$ lin. diam. for $\frac{2}{3}$ of its length, upper part much enlarged, subcampanulate; lobes about 5 lin. long, hatchet-shaped, with an incurved apiculus, one side being dilated into a subrectangular, obtuse, membranous lobe. Stamens 5, included, inserted at the top of the narrow part of the tube; filaments about $\frac{3}{4}$ lin. long, elliptic, glabrous; anthers 2 lin. long, linear-oblong, subacute, slightly narrowed at the emarginate or shortly cordate base. Disk of 5 oblong lobes. Ovary glabrous; style about $1\frac{1}{4}$ in. long, filiform, glabrous; stigma subquadrate when viewed sideways, obtuse, 5-winged.

Kotinga Valley, 3000 ft., *McConnell & Quelch*, 132, 194.

Mandevilla scaberula, N. E. Brown, sp. n. Caules volubiles, puberuli. Folia distantia, petiolata, oblonga, obtusa, apiculata, basi cordata, supra scaberula, subtus tomentosa, reticulato-venosa. Racemi axillares, multiflori, puberuli. Bracteæ oblongæ vel oblongo-lanceolatæ. Pedicelli brevi. Calycis lobi ovati, acuti, intra squama ovata instructi. Corolla 2 poll. longa, infundibularis, extra pubescens, intra ad insertionem staminum pilis deflexis dense barbata, tubo curvato inferne angusto basi leviter inflato, superne ampliato subcampanulato, lobis dolabriformibus. Stamina inclusa, filamentis linearibus dense barbatis, antheris acutis basi cordatis obtusis.

Stem twining, $1\frac{1}{4}$–$1\frac{1}{3}$ lin. thick, puberulous. Leaves opposite, very distant, $2\frac{1}{2}$–$3\frac{1}{2}$ in. long, $1\frac{1}{4}$–2 in. broad, oblong, obtuse, apiculate, cordate at the base, scaberulous above, finely greyish-tomentose beneath, reticulated with dark veins; petiole $1\frac{1}{2}$–2 lin. long, puberulous. Racemes axillary, from one axil, 2–3 in. long, including the $\frac{3}{4}$ in. long peduncle, many-flowered, densely puberulous in all parts. Bracts about 2 lin. long, $1\frac{2}{3}$–$1\frac{1}{2}$ lin. broad, oblong or oblong-lanceolate, acute, thin, spreading, deciduous. Pedicels alternate, 2–3 lin. long, moderately stout. Calyx-lobes $1\frac{1}{3}$ lin. long and nearly as broad, ovate, acute, each with an ovate acute slightly toothed scale at its base inside. Corolla about 2 in. long, funnel-shaped, curved, 5-lobed, pubescent outside, densely bearded with deflexed white hairs at the insertion of the stamens within, elsewhere glabrous; the lower half of the tube is slightly inflated at its base and there about $2\frac{1}{2}$ lin. diam., narrowed above to $1\frac{1}{2}$ lin. diam.; the upper half much enlarged, funnel-shaped or subcampanulate; lobes about $\frac{3}{4}$ in. long, hatchet-shaped, one side being dilated into a large subquadrate, obtusely rounded, membranous lobe. Stamens 5, included, inserted at the top of the narrow part of the tube; filaments short, flat, linear, densely bearded on the inner face; anthers $2\frac{1}{2}$ lin. long, linear-oblong, acute, shortly cordate at the base, connate, adnate to the stigma. Disk tubular, $\frac{3}{4}$ lin. deep, 5-crenate. Ovary pubescent; style about $1\frac{1}{4}$ in. long, very slender, glabrous; stigma conical, 5-winged.

Tolimbaru Creek near Mount Roraima, *McConnell & Quelch*, 146.

ASCLEPIADACEÆ.

DITASSA TAXIFOLIA, Decne. in DC. Prod. viii. p. 578.

Kotinga Valley, *McConnell & Quelch*, 165, 166. Ireng Valley, *McConnell & Quelch*, 323.

LOGANIACEÆ.

BONYUNIA MINOR, N. E. Brown, sp. n. (Plate 9, figs. 1–5.) Frutex glaber. Folia opposita, approximata, breviter petiolata, coriacea, rotundato-ovata, subacuta, basi rotundata vel leviter cordata. Cymæ subdensæ, ramulis puberulis, floribus sessilibus bracteolatis. Calyx campanulatus, minute puberulus, dentibus deltoideis subacutis. Corollæ tubus subcylindricus, extra pubescens, intra parte inferiore puberulus, superiore glaber; lobi patentes, recurvi, superne carinato-incrassati, superne etiam carina et marginibus puberuli, area basali triangulare glabri. Ovarium breviter pilosum, stylo pubescente, stigmate bilobo.

A shrub. Branches terete, glabrous, dark brown. Leaves opposite, subimbricate, ascending, shortly petiolate, coriaceous, glabrous; petiole 1 lin. long; blade $\frac{2}{3}$–$1\frac{1}{4}$ in. long, $\frac{1}{2}$–1 in. broad, roundish-ovate, subacute, broadly rounded or slightly cordate at the base, with prominent veins beneath. Cymes terminal, rather dense, 1–$1\frac{1}{4}$ in. diam., with puberulous branches 2–4 lin. long. Flowers sessile, bracteolate. Bracteoles $\frac{2}{3}$–1 lin. long, linear or oblong-lanceolate, obtuse, minutely puberulous. Calyx about $1\frac{1}{2}$ lin. long, campanulate, puberulous, with 5 deltoid subacute teeth. Corolla tubular, with 5 spreading recurved lobes; tube $3\frac{1}{2}$ lin. long, subcylindric, pubescent outside, puberulous within in the lower $\frac{2}{3}$, glabrous above; lobes about $2\frac{1}{2}$ lin. long, spreading, recurved, thickened and keeled in the upper half and along the margins below and there densely puberulous, enclosing a narrowly triangular glabrous basal area. Stamens 5, inserted at the mouth of the tube, glabrous; filaments ¼ lin. long, slender; anthers about 1 lin. long, partly exserted, linear, acute. Ovary shortly hairy; style 1⅔–1¾ lin. long, pubescent; stigma 2-lobed. Capsule 4–6 lin. long, 2½–3 lin. diam., ellipsoidal, sparingly pubescent or nearly glabrous, 2-valved.

Kotinga Valley, *McConnell & Quelch*, 161. Ireng Valley, *McConnell & Quelch*, 331.

Antonia ovata, Pohl, Pl. Bras. ii. p. 13, t. 109.

Kotinga Valley, *McConnell & Quelch*, 164. Upper slopes of Mount Roraima, *McConnell & Quelch*, 324.—Only known from Brazil and Guiana.

GENTIANACEÆ.

Schultesia brachyptera, Cham. in Linnæa, viii. (1833), p. 8.

Kotinga Valley, *McConnell & Quelch*, 148.

Schultesia heterophylla, Miq. in Linnæa, xix. (1847), p. 136.

Ireng Valley, *McConnell & Quelch*, 249.

Schultesia Benthamiana, Klotzsch, ex Griseb. in Linnæa, xxii. (1849), p. 34.

Ireng Valley, *McConnell & Quelch*, 247 (and 224, apparently a starved state).

Coutoubea reflexa, Benth. in Ann. Nat. Hist. ii. (1839), p. 442.

Kotinga Valley, *McConnell & Quelch*, 141.

Coutoubea spicata, Aubl. Pl. Guian. i. p. 72.

Ireng Valley, *McConnell & Quelch*, 221, 259.

Lisianthus Imthurnianus, Oliver, in Trans. Linn. Soc. Ser. II. Bot. ii. (1887), p. 279.

Summit of Mount Roraima, *McConnell & Quelch*, 101, 682.—Endemic.

Lisianthus uliginosus, Griseb. Gen. et Sp. Gent. p. 181.

Kotinga Valley, *McConnell & Quelch*, 172. Ireng Valley, 204, 252. Upper slopes of Mount Roraima (a small-flowered form), *McConnell & Quelch*, 15.—Widely dispersed in Guiana and Brazil.

Lisianthus Quelchii, N. E. Brown, sp. n. (Plate 9, figs. 6–9.) Fruticulus glaber, ramis tetragonis internodiis 1½–6 lin. longis. Folia opposita, petiolata, oblonga vel elliptico-oblonga vel obovata, subacuta vel obtusa et apiculata, coriacea. Flores 1–3-ni ad apices ramorum, pedicellati. Calyx campanulatus, profunde 5-lobus, lobis oblongis obtusis. Corolla 1–1½ poll. longa, subinfundibularis, curvata, lobis rotundatis obtusis. Stamina inclusa, filamentis apice recurvis, antheris erectis. Ovarium ovoideum, glabrum, in stylum elongatum angustatum, stigmate bilobo.

A dwarf shrub, glabrous in all parts. Branches 4-angled, 1–1½ lin. thick, with internodes 1½–6 lin. long, leafy at the summit only, minutely tuberculate-rugulose.

Leaves opposite, petiolate, coriaceous; petiole 1–2½ lin. long; blade ¾–1¾ in. long, ⅓–1 in. broad, oblong, elliptic or obovate, subacute or obtuse and apiculate, more or less acute at the base, slightly revolute along the margins, with the midrib impressed above, prominent beneath, and the veins invisible. Flowers terminal, solitary or in a sessile 3- (or more ?) flowered cyme. Pedicels 2–4 lin. long, rather stout, slightly rough from minute tubercles. Bracts and bracteoles ⅓–1 lin. long, acuminate. Calyx 3½–4 lin. long, campanulate, deeply 5-lobed; lobes 2½–3 lin. long, oblong, obtuse. Corolla 1–1½ in. long, somewhat funnel-shaped, 5-lobed, curved or oblique; lobes 3½–4½ lin. long and broad, suborbicular, contracted at the base. Stamens included; filaments filiform, recurved near the apex and then shortly curved upwards at the very apex; anthers erect, 2–2⅓ lin. long, oblong subobtuse, cordate at the base. Ovary ovoid, narrowed into the 5 lin. long style, with a shortly 2-lobed stigma.

Summit of Mount Roraima, 8600 ft., *McConnell & Quelch*, 106, 649.

A very distinct species, perhaps nearer to *Lisianthus ovalis*, Ruiz & Pav., than to any other.

Lisianthus Elisabethæ, Griseb. in Linnæa, xxii. (1849), p. 40.

Lisianthus aff. *L. macrantho,* Oliver, in Trans. Linn. Soc. Ser. II. Bot. ii. (1887), p. 279.

Leiothamnus Elisabethæ, R. H. Schomb. in Verh. des Ver. Beförd. Gartenb. in Preuss. xviii. (1847), p. 155, t. 1; R. Schomb. Bot. Rem. Brit. Guiana, p. 77.

Upper slopes and ledge of Mount Roraima, *im Thurn*, 188; *McConnell & Quelch*, 25.—Endemic.

HYDROPHYLLACEÆ.

Hydrolea spinosa, Linn. Sp. Pl. ed. 1, p. 328.

Ireng Valley, *McConnell & Quelch*, 262. Kotinga Valley, *McConnell & Quelch*, 180. Savannahs generally, *McConnell & Quelch*, 313.

BORAGINACEÆ.

Heliotropium strictissimum, Moric. ?, Pl. Nouv. Am. p. 146, t. 87.

Ireng Valley, *McConnell & Quelch*, 220, 302.

CONVOLVULACEÆ.

Ipomœa irengana, N. E. Brown, sp. n. Caulis gracilis, volubilis, subpubescens, internodiis ⅓–1 poll. longis. Folia parva, petiolata, late cordata, obtusa, minute apiculata, supra velutina, subtus albo-tomentosa. Flores axillares, solitarii, pedicellati. Calycis lobi oblongi, obtusi, puberuli. Corolla 1¼–1½ poll. longa, extra pubescens, purpurea.

Stems very slender, twining, woody below, slightly pubescent, with internodes ⅓–1 in. long. Leaves small; petiole 2–5 lin. long, slender, terete, pubescent; blade ⅓–1 in. long, ⅓–¾ in. broad, cordate or roundish-cordate, obtuse, minutely apiculate, velvety-tomentose above, whitish-tomentose beneath. Flowers axillary, solitary. Pedicels 2–2½ lin. long, very minutely bracteolate at the base, pubescent. Sepals subequal, 3½–4 lin. long, 1½ lin. broad, oblong, obtuse, thinly pubescent or puberulous. Corolla 1¼–1½ in. long, funnel-shaped, pubescent outside, purple. Stamens included; filaments pubescent at their base. Ovary and style glabrous; stigma of 2 globose lobes.

Ireng Valley, on ant-hills, *McConnell & Quelch*, 251, 265.

JACQUEMONTIA EVOLVULOIDES, Meissn. in Mart. Fl. Bras. vii. p. 307.
Ireng Valley, *McConnell & Quelch*, 233.

EVOLVULUS STRICTUS, Benth. in Hook. Lond. Journ. Bot. v. (1846), p. 354.
Ireng Valley, *McConnell & Quelch*, 218, 219, 261.

EVOLVULUS SERICEUS, Sw. Prod. Veg. Ind. Occ. p. 55.
Ireng Valley, *McConnell & Quelch*, 215.

SOLANACEÆ.

SOLANUM CRINITUM, Lam. Illust. ii. p. 20.
Ireng Valley, near Mataruka Mountain, *McConnell & Quelch*, 134.

SCROPHULARIACEÆ.

BEYRICHIA SCUTELLARIOIDES, Benth. Scroph. Ind. p. 9, in nota.

B. ocymoides, Oliver, in Trans. Linn. Soc. Ser. II. Bot. ii. (1889), p. 280, not of Cham.

Upper slopes of Mount Roraima, *McConnell & Quelch*, 5.—Trinidad and Brazil.

HERPESTIS GRATIOLOIDES, Benth. in Hook. Comp. Bot. Mag. ii. (1836), p. 57.
Ireng Valley, *McConnell & Quelch*, 266.

GERARDIA HISPIDULA, Mart. Nov. Gen. & Sp. iii. p. 13, t. 207.
Ireng Valley, *McConnell & Quelch*, 232.

BUCHNERA PALUSTRIS, Spreng. Syst. ii. p. 805.
Ireng Valley, *McConnell & Quelch*, 234.

BUCHNERA, sp. Too imperfect for determination.
Ireng Valley, *McConnell & Quelch*, 236, 238.

LENTIBULARIACEÆ.

UTRICULARIA HUMBOLDTII, R. H. Schomb. in Verh. des Ver. Beförd. Gartenb. in Preuss. xv. (1841), p. 139, t. 3; R. Schomb. Reisen in Brit.-Guiana, ii. p. 263, & iii. p. 1086; im Thurn & Oliver, in Trans. Linn. Soc. Ser. II. Bot. ii. (1889), pp. 256, 262, 265, 267, 269, & 280.

Upper slopes of Mount Roraima, *McConnell & Quelch*, 3.—Also on the Kaieteur Savannah.

UTRICULARIA ALPINA, Jacq. Enum. Pl. Carib. p. 11.

U. montana, Jacq. Select. Stirp. Amer. p. 7, t. 6.

Upper slopes of Mount Roraima, growing on trees, *McConnell & Quelch*, 43. Roraima

Range, 3500 ft., *McConnell & Quelch*, 718.—Also in the West Indies, Venezuela, Colombia, Peru, and Ecuador.

Utricularia Campbellianum, Oliver, in Trans. Linn. Soc. Ser. II. Bot. ii. (1887), p. 280, t. 44. f. B, & pp. 266, 267, & 270.

Upper slopes of Mount Roraima, on trees, *McConnell & Quelch*, 35.—Endemic.

Utricularia Quelchii, N. E. Brown, sp. n. (Plate **10**, figs. 12–16.) Perennis. Folia spathulata, longe petiolata, coriacea, glabra. Caulis 2–5 poll. altus, 1–2-squamosus, 1–2-florus, glaber. Bracteæ et bracteolæ 2–3½ lin. longæ, oblongæ vel elliptico-oblongæ, obtusæ, glabræ. Sepala magna, elliptica, obtusa. Corolla magna, labio superiore ovato et obtuso et apice recurvo, labio inferiore multo majore orbiculare reflexo, calcare ad medium abrupte procurvo subobtuso.—*Utricularia* aff. *U. montanæ*, Jacq.; Oliver, in Trans. Linn. Soc. Ser. II. Bot. ii. (1887), p. 280.

Perennial. Roots fibrous and tuberous intermixed. Leaves all radical, erect, spathulate, coriaceous, glabrous; petiole ¾–2 in. long; blade ½–1 in. long, 3–5 lin. broad, obovate or narrowly elliptic, obtuse, cuneately narrowed into the petiole. Stem 2–5 in. long, ½–⅔ lin. thick, 1–2-flowered, glabrous, bearing 1–2 lanceolate, acute, glabrous scales 1–2½ lin. long. Bracts and bracteoles subequal, basifixed, 2–3½ lin. long, 1–1½ lin. broad, oblong or elliptic-oblong, obtuse, glabrous, not ciliate. Pedicels 4–6 lin. long, glabrous. Sepals 4½–6 lin. long, 3½–4 lin. broad, elliptic, obtuse, concave, glabrous. Corolla large, glabrous, purple or deep red; upper lip 3–4 lin. long, included in the dorsal sepal, erect, recurved at the apex, ovate, obtuse, with the sides abruptly reflexed around the mouth, then again curved forwards; lower lip 7–9 lin. long, 8–15 lin. broad, abruptly reflexed from the mouth of the spur, suborbicular, very obtuse, entire; spur ¾–1 in. long, gradually tapering from the 2½–3 lin. broad mouth to the obtuse apex, with the basal half hanging straight down and partly embraced by the lower sepal, and the apical half abruptly curved forwards or upwards. Stamens with thick clavate curved filaments, glabrous. Ovary globose, narrowed into a stout style, glabrous; upper lip of the stigma narrow, lower lip very broad, very obtusely rounded or subtruncate.

Summit of Mount Roraima, 8600 ft., *McConnell & Quelch*, 105, 683; *im Thurn*, 293.

Allied to *U. montana*, Jacq., but smaller, with larger petioles to the leaves, broader bracts, and differently coloured flowers, which, to judge from the dried specimens, appear to have been either purple or deep red. Probably it is the plant mentioned by Mr. Quelch in 'Timehri,' vol. ix. p. 178, as "the beautiful crimson *Utricularia montana*," since the flowers of the true *U. montana* (= *U. alpina*), Jacq. are white.

Utricularia Connellii, N. E. Brown, sp. n. (Plate **10**, figs. 1–6.) Aphylla, 1½–4 poll. alta. Caulis filiformis, 1–2-squamosus, glaber, 1–3-florus. Bracteæ et bracteolæ minutæ, ovatæ vel oblongæ, ciliatæ. Sepala elliptica, multi-nervosa, nervis pubescentibus; sepalum inferius minutum, bilobum. Corolla ringens, glabra, labio superiore erecto, anguste subspathulato-oblongo, labio inferiore suborbiculare obtuso reflexo, calcare leviter curvato subacuto.

Leafless at the time of flowering. Stems $1\frac{1}{2}$–4 in. high, filiform, glabrous, 1–2-flowered and bearing 1–2 minute, peltately attached, very minutely ciliate scales. Bracts $\frac{1}{2}$ lin. long, ovate, acute, peltately attached, minutely ciliate. Bracteoles slightly shorter than the bracts, basifixed, oblong, acute, minutely ciliate. Pedicels 1–2 lin. long, glabrous. Sepals about $1\frac{1}{2}$ lin. long, the upper nearly 1 lin. broad, ovate, subacute, the lower rather broader, emarginate at the apex, both deeply concave, strongly nerved, with a few short hairs scattered along the nerves. Corolla ringent; upper lip erect, 3–$3\frac{1}{2}$ lin. long, $\frac{3}{4}$–1 lin. broad, subspathulate-oblong, obtuse, with recurved margins, minutely puberulous inside at the base; lower lip 4–5 lin. long, about 4 lin. broad, suborbicular, obtuse, abruptly deflexed from the mouth of the spur, where it is minutely puberulous. Spur $4\frac{1}{2}$–$5\frac{1}{2}$ lin. long, nearly in a line with the upper lip, slightly curved forwards, gradually tapering from the $1\frac{1}{2}$ lin. broad base to the subacute apex, compressed. Filaments of the stamens incurved, clavate, glabrous. Ovary ovoid, narrowed into a short style, glabrous; stigma with a narrow acute upper lip and a broadly ovate obtuse lower lip.

Arabapu River, *McConnell & Quelch*, 127.

Allied to *U. cornuta*, Michx., but smaller, more slender, and with a more reflexed lower lip to the corolla.

UTRICULARIA RORAIMENSIS, N. E. Brown, sp. n. (Plate 11, figs. 1–4.) Perennis. Folia radicalia, orbiculato-spathulata, 3–7 lin. longa. Caules simplices vel divisi, $1\frac{1}{4}$–3 poll. longi, subfiliformi, 1–2-flori, 1–3-squamosi, glabri. Bracteæ minutæ, trifidæ. Flores parvi, pedicellati. Sepala inæqualia, glabra; sepalum superius ellipticum, obtusum, profunde concavum; inferius brevius, subquadratum, truncatum. Corollæ labium posticum ovatum, obtusum, intra minute glandulosum; labium anticum late subreniforme breviter 3-lobum, abrupte reflexum, minute glandulosum; calcar late conicum, obtusum, minute glandulosum.

Perennial. Leaves all radical, spathulate, glabrous; petiole 2–5 lin. long, slender; blade 1–2 lin. long, $\frac{1}{2}$–$1\frac{3}{4}$ lin. broad, obovate or orbicular, obtuse, cuneate at the base. Stems 1–4 to a plant, simple or once branched, $1\frac{1}{4}$–3 in. high, subfiliform, 1–2-flowered, glabrous, bearing 1–3 minute, oblong, obtuse, glabrous scales. Bracts minute, trifid, with the lateral teeth narrow and acute, and the middle tooth broadly rounded, glabrous, not ciliate. Pedicels 1–$2\frac{1}{2}$ lin. long, filiform, erect. Sepals unequal, thin, glabrous; the upper $\frac{3}{4}$–1 lin. long, elliptic or elliptic-ovate, obtuse, deeply concave, with about 4 rather obscure veins; the lower $\frac{1}{2}$ lin. long, and about the same in breadth, subquadrate, truncate or very slightly emarginate, 4-veined. Corolla small; upper lip 1–$1\frac{1}{4}$ lin. long, $\frac{2}{3}$–$\frac{3}{4}$ lin. broad, ovate, obtuse, concave, erect or ascending, minutely glandular within; lower lip $1\frac{1}{3}$–$1\frac{1}{2}$ lin. long, 2 lin. broad, subreniform, shortly 3-lobed, and more or less undulated, abruptly reflexed from the mouth of the spur on which it rests, minutely glandular on the lower part; spur $1\frac{1}{2}$ lin. long, $1\frac{1}{4}$ lin. broad at the mouth, broadly conical, obtuse, compressed, minutely glandular, directed at a right angle to the pedicel. Stamens with curved clavate filaments, glabrous. Ovary globose, abruptly contracted into a stout style, glabrous; stigma with a minute tooth-like upper lip and a large truncate lower lip.

Summit of Mount Roraima, 8600 ft., *McConnell & Quelch*, 685.

UTRICULARIA CONCINNA, N. E. Brown, sp. n. (Plate **10**, figs. 7–11.) Pusilla, glabra. Pedunculus uniflorus, ¾–1 poll. longus. Bracteæ et bracteolæ lanceolatæ, obtusæ. Sepala magna, cordato-ovata. Corolla erecta, labiis calyce paulo longioribus, glabris, labio superiore elliptico vel subrectangulare et apice obscure 3-crenato, labio inferiore elliptico vel subrectangulare undulato-crenato; calcar labiis multo longius, erectum, acutum, prope apicem parcissime pilosulum.

Leaves 2–4, all radical, 3–5 lin. long, lanceolate, elliptic or oblong-lanceolate, obtuse or subacute, tapering into a short petiole at the base, glabrous, erect. Peduncle ¾–1 in. high, 1-flowered, slender, with two distant minute bracts, one near the middle, the other near the base, glabrous. Flowering-bract ⅔–1½ lin. long, lanceolate, subobtuse, glabrous, not ciliate. Bracteoles resembling the flowering-bract, but shorter and narrower. Pedicel 2–3 lin. long, glabrous. Sepals 2, erect, large in proportion to the corolla, 2½–3½ lin. long, 2–2½ lin. broad, cordate-ovate, obtuse, glabrous, not ciliate. Corolla erect, with the lips only slightly exceeding the sepals, and the spur about twice as long; upper lip 1¾–2 lin. long, and about the same in breadth, elliptic or subrectangular, obscurely 3-crenate at the apex, with recurved margins, glabrous; lower lip about 2½–2¾ lin. long, elliptic or subrectangular, crenate and wavy at the apex, with the margins recurved, glabrous; spur about 3½–3¾ lin. long, erect, acute, with a few scattered hairs on the terminal half. Stamens glabrous. Ovary globose-ovoid, narrowed into a short stout style, glabrous; stigma with a narrow acute upper lip and a broad emarginate lower lip. Capsule about half as long as the sepals, ellipsoidal, obtuse, crowned with the short style and stigma.

Kaieteur Savannah, *Jenman*, 1272; Mazaruni River, 300 ft., *McConnell & Quelch*, 710; and without precise locality, *Schomburgk*, 131.

The flowers of this diminutive species are stated by Messrs. McConnell and Quelch to be "white with purple points." I have only seen one corolla, and am uncertain if my description of it is quite correct in all details, as it was very much flattened; but my drawings of it (figs. 8 & 9) represent its general appearance as nearly as the material would allow, although they may not be accurate. The affinity of *U. concinna* is with *U. Campbelliana*, Oliver, and *U. montana*, Jacq., although it is very much smaller than either of those species.

UTRICULARIA NERVOSA, Weber ?, ex Benj. in Mart. Fl. Bras. x. p. 247.

Upper slopes of Mount Roraima, *McConnell & Quelch*, 3 *a*.

Possibly a distinct species, but the material consists of one flowering stem only, which scarcely admits of proper dissection; externally, however, it much resembles *U. nervosa*, which is a Brazilian species.

UTRICULARIA sp.

Arabapu River, *McConnell & Quelch*, 150 *a*.

The specimen consists of leafy rhizomes without flowers, which were found entangled amongst the pitchers and false roots of *Genlisea guianensis*, N. E. Brown.

GENLISEA GUIANENSIS, N. E. Brown, in Hooker, Icones Plant. t. 2629.

Arabapu River, *McConnell & Quelch*, 150.

This is the largest species of this genus at present discovered, and more nearly resembles *G. africana*, Oliver, (a native of Angola), than any other with which I am acquainted. The members of the genus *Genlisea* appear to be quite destitute of true roots, their place being supplied by modified leaves, which descend into the soil or water. Some of these modified leaves terminate in the curious tubular two-lobed utricles characteristic of the genus, others being quite simple and root-like; probably all fulfil the functions of roots, and the utricles supply an additional amount of nitrogen to the plants by the absorption of the decomposed remains of the minute animalculæ they capture. The utricles have a very remarkable structure, which will be found well described and illustrated in Darwin's 'Insectivorous Plants,' p. 446, and Goebel's 'Pflanzenbiologische Schilderungen,' ii. p. 121, t. 15–16.

GENLISEA RORAIMENSIS, N. E. Brown, sp. n. (Plate 11, figs. 5–12.) Folia obovato- vel rotundato-spathulata, crassiuscula vel subcoriacea, glabra. Utriculi biformes, alter apice bilobus, alter apice acutus, minute 1-porosi. Caulis 1½–3 poll. longus, 3–6-squamosus, minute glanduloso-hirtellus, 1–4-florus. Bracteæ et bracteolæ minutæ, lanceolatæ, acutæ. Pedicelli minute glanduloso-hirtelli. Calyx 5-lobus, minute pubescens. Corolla parva, lutea, labio superiore late ovato vel elliptico-ovato obtuso concavo glabro, labio inferiore reflexo obtuse trilobo glabro, calcari late conico obtusissimo minute glanduloso-hirtello.

A perennial with a very short branching rhizome densely covered with leaves. Leaves rosulate, 3–5 lin. long, ½–¾ lin. broad, obovate- or orbicular-spathulate, rather thick or subcoriaceous, glabrous. Utricles 2½–5 lin. long, of two forms, both tubular and ovoid-inflated at the base and descending into the soil among the roots, one (the perfect form) dividing at the mouth into two long twisted lobes, the other (a transition form) acute, with a very minute orifice at the apex and entirely without lobes; a third and imperfect form is sometimes present standing erect among the leaves in which the terminal lobes are very short and scarcely or not at all twisted. Stem simple, 1½–3 in. high, ¼–⅓ lin. thick, 1–4-flowered, minutely and rather sparsely glandular-hairy, bearing 3–6 lanceolate, acute, basifixed, glabrous scales about ⅔ lin. long. Bracts and bracteoles subequal, basifixed, about ¾ lin. long, lanceolate, acute, sparsely pubescent and ciliate. Pedicels 1–2 lin. long, glandular-pubescent. Calyx 5-lobed almost to the base; lobes ¾–1 lin. long, oblong-lanceolate, acute, thinly pubescent and slightly ciliate. Corolla small, yellow; upper lip 1½ lin. long, 1 lin. broad, broadly ovate or elliptic-ovate, obtuse, concave, glabrous; lower lip 2 lin. long and as much in breadth, reflexed, obtusely 3-lobed, glabrous; spur 1¼ lin. long, 1¼ lin. broad at the mouth, stout, conical, very obtuse, compressed, slightly and minutely glandular-hairy, and darker in colour than the rest of the flower. Stamens glabrous; filaments curved, clavate; anthers deep blue. Ovary globose, thinly covered with very minute hairs; style short; stigma oblique. Capsule globose, about 1 lin. diam., minutely and sparsely hairy.

Summit of Mount Roraima, 8600 feet, growing in a somewhat sandy boggy soil, *McConnell & Quelch*, 684.

BIGNONIACEÆ.

Tabebuia Roraimæ, Oliver, in Trans. Linn. Soc. Ser. II. Bot. ii. (1887), p. 280, t. 45.
Upper slopes of Mount Roraima, *McConnell & Quelch*, 33.—Endemic.

ACANTHACEÆ.

Ruellia Vindex, Mart. ex Nees in Mart. Fl. Bras. ix. p. 42.
Ireng Valley, *McConnell & Quelch*, 253.

Thyrsacanthus Schomburgkianus, Nees, in Hook. Lond. Journ. Bot. iv. (1845), p. 636.
Upper Essequebo River, *McConnell & Quelch*, 277.

Dianthera guianensis, N. E. Brown, sp. n. Caulis bifariam pubescens. Folia subsessilia, lanceolata vel ovato-lanceolata, acuta, basi angustata rotundata, utrinque glabra vel sparsim pubescentia. Thyrsus terminalis, subspiciformis, pedunculatus. Bracteæ et bracteolæ lineari-lanceolatæ, acutissimæ, subglabræ, ciliatæ. Sepala 5, libera, lineari-lanceolata, acutissima, pubescentia, ciliata. Corolla superne pubescens, labio superiore oblongo marginibus reflexo apice minute bilobo, labio inferiore 3-lobo disco plicato-elevato.—*Justicia* sp., Oliver, in Trans. Linn. Soc. Ser. II. Bot. ii. (1887), p. 280.

Shrubby, with terete, bifariously pubescent branches. Leaves spreading, subsessile, 2–4 in. long, 7–18 lin. broad, lanceolate or ovate-lanceolate, acute, narrowed below the middle to a rounded base, glabrous or sparsely pubescent on both sides. Peduncles terminal, $\frac{3}{4}$–$3\frac{1}{2}$ in. long, naked or bibracteate. Thyrsus spike-like, moderately dense, 1–$2\frac{1}{2}$ in. long, 1–$1\frac{1}{2}$ in. diam. Bracts and bracteoles $2\frac{1}{2}$–$3\frac{1}{2}$ lin. long, linear-lanceolate, very acute, glabrous or slightly pubescent and slightly ciliate. Sepals 5, free, 3–$3\frac{1}{2}$ lin. long, $\frac{2}{3}$ lin. broad, linear-lanceolate, very acuminate, pubescent, ciliate. Corolla two-lipped, pubescent in the upper part outside, apparently purple or red, spotted with darker; tube $\frac{1}{4}$ in. long; upper lip $4\frac{1}{2}$ in. long, oblong, with reflexed margins and minutely 2-lobed at the apex; lower lip $5\frac{1}{2}$ lin. long, 3-lobed, with an elevated plicate disk. Stamens 2, inserted at the middle of the tube; anthers 2-celled, with unequal cells, obtuse at each end, separated by a broad connective.

Kotinga Valley, *McConnell & Quelch*, 188; Kukenaam Valley, *im Thurn*, 81; Mount Roraima, *Appun*, 1387.

VERBENACEÆ.

Lippia Schomburgkiana, Schauer, in DC. Prod. xi. p. 577; Oliver, in Trans. Linn. Soc. Ser. II. Bot. ii. (1887), p. 280.

Upper slopes of Mount Roraima, *McConnell & Quelch*, 2; Roraima Range, 3500 ft., *McConnell & Quelch*, 720; Ireng Valley, *McConnell & Quelch*, 235.

I doubt if this Guiana plant is really distinct from the Brazilian *L. glandulosa*, Schauer, described at the same place.

STACHYTARPHETA MUTABILIS, Vahl, Enum. i. p. 208.
Ireng Valley, *McConnell & Quelch*, 245.

LABIATÆ.

HYPTIS ARBOREA, Benth. in DC. Prod. xii. p. 132.
Kotinga Valley, *McConnell & Quelch*, 142, 184.

AMARANTACEÆ.

GOMPHRENA GLOBOSA, Linn. Sp. Pl. ed. 1, p. 224.
At Pelepowta Village in the Ireng Valley, *McConnell & Quelch*, 210.

PHYTOLACCACEÆ.

PHYTOLACCA THYRSIFLORA, Fenzl, ex J. A. Schmidt in Mart. Fl. Bras. ii. p. 343.
Kotinga Valley, *McConnell & Quelch*, 152.

PROTEACEÆ.

ROUPALA MONTANA, Aubl. Pl. Guian. i. p. 83.
Savannahs generally, *McConnell & Quelch*, 310.

LORANTHACEÆ.

PHORADENDRON RORAIMÆ, Oliver, in Trans. Linn. Soc. Ser. II. Bot. ii. (1887), p. 281, and pp. 267, 269.
Summit of Mount Roraima, *McConnell & Quelch*, 82, 680.—Endemic.

BURMANNIACEÆ.

BURMANNIA BICOLOR, Mart. Nov. Gen. & Sp. i. p. 10, t. 5; R. Schomb. Reisen in Brit.-Guiana, iii. p. 1066.

Upper slopes of Mount Roraima, *McConnell & Quelch*, 14.—Widely dispersed in Tropical America from Cuba to Brazil, westward to Peru.

ORCHIDACEÆ. By R. A. ROLFE, A.L.S.

PLEUROTHALLIS RORAIMENSIS, Rolfe, sp. n. Lepanthiformis, caulibus gracilibus, vaginis apice ciliatis. Folia elliptica vel obovato-elliptica, minute apiculata, parva. Scapi subelongati, gracillimi, pauciflori. Bracteæ spathaceæ. Sepalum posticum basi ovatum, apice caudato-acuminatum; sepala lateralia subsimilia, basi angustiora. Petala oblonga, obtusa. Labellum trilobum, lobis lateralibus rotundatis, intermedio oblongo obtuso.

Stems slender, $\frac{1}{2}$ in. long, clothed with three or four angular or striate sheaths, broader and ciliate at the apex. Leaves elliptical or obovate-elliptical, minutely apiculate, $2\frac{1}{2}$–4 lin. long, $1\frac{1}{2}$–2 lin. broad. Scapes very slender, $\frac{3}{4}$–1 in. long, about 2- or

3-flowered. Bracts spathaceous, minute. Pedicels 1½ lin. long. Dorsal sepal ovate at the base, caudate-acuminate above, 2 lin. long; lateral similar, but narrower at the base. Petals oblong, obtuse, 1 lin. long, thinly membranaceous. Lip trilobed, 1 lin. long; side lobes spreading, broadly rounded; front lobe oblong, obtuse; disc bearing a pair of thickened nerves. Column clavate, ¾ lin. long.

Roraima, summit, 8600 ft., *McConnell & Quelch*, 687.—Endemic.

Allied to the Colombian *Pleurothallis intricata*, Lindl., but smaller in all its parts, besides being different in structure. The species of the natural group *Lepanthiformes*, to which it belongs, were distributed by Lindley into three sections, owing to the exigencies of an admittedly artificial arrangement, which would place the present one in the section *Acuminatæ*.

Stelis guianensis, Rolfe, sp. n. Cæspitosa. Caules brevissimi. Folia oblanceolato-oblonga, subobtusa, basi subattenuata. Scapi graciles, multiflori. Bracteæ triangulari-ovatæ, acutæ. Pedicelli breves. Sepala orbiculari-ovata, obtusa, basi connata. Petala suborbicularia, concava. Labellum integrum, suborbiculare, petalis paullo angustius.

A dwarf, densely-tufted plant, with very short stems. Leaves oblanceolate-oblong, subobtuse, somewhat attenuate at the base, 4–9 lin. long, 1½–2 lin. broad. Scapes slender, 2½ in. long, many-flowered. Bracts triangular-ovate, acute, ½ lin. long. Pedicels ¾ lin. long. Sepals orbicular-ovate, obtuse, ¾ lin. long, slightly pubescent, the basal fourth connate. Petals broadly orbicular, somewhat concave, not half as long as the sepals. Lip entire, rather narrower than the petals, but otherwise very similar.

Roraima range, 3500 ft., *McConnell & Quelch*, 703.—Endemic.

A species belonging to Lindley's small group *Monastachyæ apodæ*, and allied to the Peruvian *S. pusilla*, H. B. & K. A specimen collected at the Kaieteur Savannah, Potaro River, British Guiana, by Jenman (1055), is either a form of the same or a closely allied species.

Brachionidium brevicaudatum, Rolfe, sp. n. Caulis primarius repens, brevis; secundarius brevissimus. Folia breviter petiolata, elliptico-lanceolata, tridenticulata. Pedunculi filiformes, uniflori. Bracteæ apice acuminatæ. Sepalum posticum ovatum, apice abrupte acuminatum vel brevissime caudatum; sepala lateralia omnino connata et postico subsimilia. Petala ovata, acuminata vel brevissime caudata, margine plus minusve ciliata. Labellum sessile, trilobum, lobis lateralibus falcato-oblongis subobtusis, intermedio reflexo late ovato-rotundato. Columna lata.

Primary stem creeping, with short internodes, clothed with membranaceous sheaths; secondary very short, clothed with about two tubular membranaceous sheaths having a short acuminate apex. Leaves shortly petioled, elliptical-lanceolate, shortly tricuspidate, 8–10 lin. long, 2½–3½ lin. broad; petioles 1½–2 lin. long. Peduncles slender, ¾–1¼ in. long, bearing a short tubular acuminate sheath above the middle. Bract similar to the sheath but rather larger. Dorsal sepal ovate, abruptly acuminate or shortly caudate, 4 lin. long by nearly 3 lin. broad, trinerved; lateral pair united into a body closely resembling the dorsal sepal, but rather broader and 4-nerved. Petals ovate, shortly acuminate, 3 lin. long, more or less ciliate, trinerved. Lip sessile, 1½ lin. long, trilobed; side lobes falcate-oblong, subobtuse, suberect; front lobe reflexed, broadly rounded-oblong; disc with a slightly elevated crest between the side lobes. Column broad, ½ lin. long.

Roraima range, 3500 ft., *McConnell & Quelch*, 705.—Endemic.

An interesting addition to this small genus, readily distinguished from its allies by the short secondary stem, and short tails to the sepals and petals.

MASDEVALLIA PICTURATA, Reichb. f. Otia Bot. Hamb. 16; Ridl. in Trans. Linn. Soc. Ser. II. Bot. ii. (1887), p. 281; Woolw. Masd. p. 87, t. 34.

Roraima, at 3500 ft., *McConnell & Quelch*, 704; Upper slope, *im Thurn*, 279.

In the mountains of Colombia, between 2500 and 6500 ft. elevation; extending along the Coast Andes of Venezuela to Caracas, at 6000 to 6500 ft.; also in Costa Rica. Roraima seems to be an outlying station for the species.

OCTOMERIA CONNELLII, Rolfe, sp. n. Caules secundarii elongati. Folia subsessilia, oblongo-lanceolata, subobtusa, crasso-coriacea. Flores subfasciculati, mediocres. Sepala et petala ovato-lanceolata, subobtusa. Labellum oblongum, subconcavum, obtusum vel obscure tridentatum, margine minutissime crenulatum.

Secondary stems stout, elongate, 4–12 in. long, clothed with four or five tubular sheaths 1–1½ in. long. Leaf subsessile, thickly coriaceous or somewhat fleshy, oblong-lanceolate, subobtuse, 2–4 in. long, 4–10 lin. broad. Flowers few, or produced mostly in succession, medium-sized, shortly pedicelled. Sepals and petals ovate-lanceolate, subobtuse, 4–6 lin. long. Lip oblong, somewhat concave, obtuse or obscurely tridentate, margin minutely crenulate, 3–4 lin. long. Column clavate, 1½ lin. long.

Roraima, summit at 8600 ft., *McConnell & Quelch*, 700.—Endemic.

A very distinct species, having stems much longer than the leaves, and flowers comparatively large for the genus. It is comparable with *O. grandiflora*, Lindl., but has longer stems, much shorter leaves, and the lip very different in structure.

OCTOMERIA PARVIFOLIA, Rolfe, sp. n. Cæspitosa. Caules secundarii graciles, vaginis tubulosis striatis obtecti. Folia lineari-oblonga, subacuta, parva. Flores fasciculati. Sepala ovato-oblonga, subobtusa. Petala lineari-oblonga, subobtusa. Labellum late deltoideo-trilobum, lobis lateralibus divergentibus anguste triangularibus, intermedio breviter et late triangulari obtuso.

Secondary stems densely tufted, slender, 2½–3 in. long, clothed with about five or six tubular striate sheaths. Leaves linear-oblong, subacute, ¾–1¼ in. long, 1–1½ lin. broad, base somewhat attenuate. Flowers fasciculate. Pedicels very short. Sepals ovate-oblong, subobtuse, 1 lin. long. Petals linear-oblong, subobtuse, 1 lin. long. Lip broadly deltoid-triangular, over ½ lin. broad; side lobes narrowly triangular, subobtuse; front lobe broadly triangular, obtuse; disc with a pair of thickened slightly arcuate keels in the centre, and a shorter one in front. Column short.

Roraima, summit, 8600 ft., *McConnell & Quelch*, 696.—Endemic.

In the relatively small proportion which the leaf bears to the rest of the plant, this species approaches the Brazilian *Octomeria breviflora*, Cogn., but the structure of the lip is very different.

BULBOPHYLLUM RORAIMENSE, Rolfe, sp. n. Racemus multiflorus. Bracteæ oblongæ vel ovato-oblongæ, acutæ. Sepala ovato-lanceolata, acuminata, lateralia carinata. Petala ovato-oblonga, subacuta. Labellum velutinum, pandurato-oblongum, obtusum, medio ad basin lateraliter compressum, basi utrinque auriculatum, disco elevato bicarinato. Columna brevis, utrinque bidentata.

Scape moderately slender; raceme 3 in. long, many-flowered. Bracts oblong or ovate-oblong, acute, 2½–3 lin. long. Pedicels 1 lin. long. Sepals ovate-lanceolate, acuminate, 4–5½ lin. long, lateral carinate. Petals ovate-oblong, subacute, 1½ lin. long. Lip 2¾ lin. long, velvety, pandurate-oblong, obtuse; front lobe expanded into an ovate-oblong blade, middle and base laterally compressed, with a rounded erect basal auricle on either side; disc much elevated and channelled between the pair of obtuse keels. Column stout, 1 lin. long, with two pairs of teeth; upper pair subulate-filiform, incurved, with a broad base, as long as the column, lower pair subulate-oblong, a third as long as the upper.

Roraima, summit, 8600 ft., *McConnell & Quelch*, 103.—Endemic.

Allied to *B. geraense*, Reichb. f., but the scape and raceme more slender, the sepals proportionately broader, and the lip and teeth of the column different in detail. It is described from a single scape.

ELLEANTHUS LINIFOLIUS, Presl, Rel. Haenk. p. 97.

Ireng Valley, *McConnell & Quelch*, 301. Roraima, *Schomburgk*.—Also found in Cuba, Porto Rico, Nicaragua, Panama, Guiana, Brazil, and Bolivia.

DIACRIUM BICORNUTUM, Benth. in Journ. Linn. Soc., Bot. xviii. (1881), p. 312.

Kwaimatta Savannah, *McConnell & Quelch*, 280.—Also found in Guiana, Trinidad, and Tobago.

EPIDENDRUM GRANITICUM, Lindl. in Hook. Journ. Bot. iii. (1841), p. 83.

Kwaimatta Savannah, Rupununi River, *McConnell & Quelch*, 279. Ireng River, *im Thurn*, 13.—Found in British and Dutch Guiana, and Trinidad.

Nearly allied to *E. oncidioides*, Lindl., with which it is made synonymous by Lindley.

EPIDENDRUM SCHOMBURGKII, Lindl. Bot. Reg. (1838), Misc. p. 15; Ridl. in Trans. Linn. Soc. Ser. II. Bot. ii. (1887), p. 281.

Kotinga Valley, *McConnell & Quelch*, 135. "Flowers red, of all shades."—Found in Trinidad, Guiana, Brazil, and Bolivia.

EPIDENDRUM FULGENS, Brongn. in Duperry, Voy. Coquille, Phan. p. 196, t. 43; Rolfe, in Orch. Rev. v. (1897), p. 264.

E. Schomburgkii, var. *confluens*, Lindl. Fol. Orch., Epidendr. p. 70.

E. Schomburgkii, Appun, Unter den Tropen, ii. p. 199 (non Lindl.).

Roraima, upper slopes, *McConnell & Quelch*, 1. North of Roraima, *Appun*, 1202. "Abundant."—Found in British Guiana, and the Brazilian provinces of Rio de Janeiro and Santa Catherina.

Epidendrum elongatum, Jacq. Coll. iii. p. 260; and Ic. Pl. Rar. iii. p. 17, t. 604; Ridl. in Trans. Linn. Soc. Ser. II. Bot. ii. (1887), p. 281.

Roraima, summit, at 8600 ft., *McConnell & Quelch*, 686. South side, at 5500 ft., *im Thurn*, 42.—Found in the Windward Islands, W. Indies, from Antigua to Trinidad, also in Guiana, Brazil, and Bolivia.

Epidendrum alsum, Ridl. in Trans. Linn. Soc. Ser. II. Bot. ii. (1887), p. 281.

Roraima, summit, 8600 ft., *McConnell & Quelch*, 90, 699; *im Thurn*, 296.—Endemic.

Epidendrum Imthurnii, Ridl. in Trans. Linn. Soc. Ser. II. Bot. ii. (1887), p. 282, t. 46. fig. A.

Roraima, summit, 8600 ft., *McConnell & Quelch*, 697; *im Thurn*, 299.—Endemic.

Epidendrum montigenum, Ridl. in Trans. Linn. Soc. Ser. II. Bot. ii. (1887), p. 282.

Roraima, upper slopes and summit, *McConnell & Quelch*, 37, 694; ledge and top, *im Thurn*, 322.—Endemic.

Epidendrum violascens, Ridl. in Trans. Linn. Soc. Ser. II. Bot. ii. (1887), p. 282, t. 46. fig. B.

Roraima, summit, 8600 ft., *McConnell & Quelch*, 81, 695; *im Thurn*, 300.—Endemic.

Galeandra juncea, Lindl. Sert. Orch. sub t. 37.

Ireng Valley, *McConnell & Quelch*, 243.—Also found in Guiana and Brazil.

Cyrtopodium Andersonii, R. Br. in Ait. Hort. Kew. ed. 2, v. p. 216.

Kanuku Mts., *McConnell & Quelch*, 276.—Also found in Guiana, Brazil, and Paraguay.

Cyrtopodium cristatum, Lindl. Bot. Reg. (1841), sub t. 8.

Kotinga Valley, amid stones on hill, *McConnell & Quelch*, 136. "Flowers yellow and brown."—Also found in Trinidad, Guiana, and Brazil.

Zygopetalum Burkei, Reichb. f. in Gard. Chron. xx. (1883), p. 684; Ridl. in Trans. Linn. Soc. Ser. II. Bot. ii. (1887), p. 282.

Z. Mackaii, R. Schomb. Reisen in Brit.-Guiana, ii. p. 266, iii. p. 1068; Appun, Unter den Tropen, ii. pp. 246, 292 (non Hook.).

Roraima, upper slopes, *McConnell & Quelch*, 26. "Flowers coffee-coloured." South side, at 5500 ft., *im Thurn*, 50. South and east sides, *Appun*, 1390.—Endemic.

ERIOPSIS SCHOMBURGKII, Reichb. f. in Bonplandia, iii. (1855), p. 67.

Pseudoeriopsis Schomburgkii, Reichb. f. in Linnæa, xxii. (1849), p. 853; R. Schomb. Reisen in Brit.-Guiana, iii. p. 1123.

Roraima, upper slopes, *McConnell & Quelch*, 34. "Flowers brown." *Schomburgk*, 1679 *a*.—Also in the savannah of South Guiana.

HOULLETIA RORAIMENSIS, Rolfe, sp. n. Folia elliptico-lanceolata, magna. Scapus arcuatus, 7–9-florus. Bracteæ oblongæ, subobtusæ, concavæ. Sepala orbiculari-elliptica, concava. Petala orbiculari-elliptica, plana. Labellum profunde trilobum; lobi laterales late oblongi, truncati, oblique apiculatis; intermedius breviter unguiculatus, late trulliformis, apiculatus, callo transverso submembranaceo ad basin unguem sito. Columna clavata.

Leaf petiolate, elliptico-lanceolate, acute, 1½ ft. long, 4½ in. broad. Scape arching (base not seen); raceme 7–9-flowered. Bracts oblong, subobtuse, concave, 6–7 lin. long. Pedicels 1–1¼ in. long. Sepals orbicular-elliptical, concave, 9–11 lin. long, 7–9 lin. broad. Petals orbicular-elliptical, nearly flat, 9–10 lin. long, 7–8 lin. broad. Lip deeply 3-lobed; side lobes broadly oblong, nearly truncate and obliquely apiculate, 6 lin. long, 3½ lin. broad, connected at the base by a suberect, transverse, stout, undulate membrane, and with a somewhat similar connecting callus at the junction of the front lobe, but more distinctly toothed; front lobe shortly and broadly unguiculate, broadly trulliform, abruptly apiculate, and with subacute lateral angles, 5 lin. long by nearly as broad. Column clavate, curved, 5 lin. long.

Roraima, upper slopes, *McConnell & Quelch*, 29.—Endemic.

A very distinct species, nearest *H. Lowiana*, Reichb. f., in structure, but very different in the broad nearly truncate side lobes of the lip, and more like *H. Brocklehurstiana*, Lindl., in habit.

CATASETUM DISCOLOR, Lindl. Bot. Reg. (1844), Misc. p. 34.

Roraima, upper slopes, *McConnell & Quelch*, 6.—Also found in Guiana, Brazil, and Paraguay.

MAXILLARIA CONNELLII, Rolfe, sp. n. Folia oblongo-lanceolata, acuta, basi in petiolum attenuata. Scapus foliis brevior, vaginis ovato-lanceolatis acutis subimbricatis obtectus. Bractea oblongo-lanceolata, acuta. Sepala subobtusa et minute apiculata; sepalum lateralia triangulari-oblonga; posticum oblongo-lanceolatum. Petala oblongo-lanceolata, subacuta. Labellum elliptico-oblongum, obtusum, subundulatum, apice recurvum, callo oblongo apice dilatato truncato. Columna brevis

Leaves oblong-lanceolate, acute, attenuate at the base, 6–8 in. long, 9–12 lin. broad. Scape 3½–4 in. long, covered with ovate-lanceolate acute sheaths, 6–9 lin. long and somewhat imbricate at the base. Bract oblong-lanceolate, acute, 9–12 lin. long. Sepals subobtuse and minutely apiculate, dorsal oblong-lanceolate, 7–8 lin. long; lateral triangular-oblong, 8–9 lin. long. Petals oblong-lanceolate, subacute, 7–8 lin. long. Lip elliptical-oblong, obtuse, somewhat undulate, recurved at the apex, rather fleshy, 5–6 lin. long; callus oblong, dilated and truncate at the apex. Column stout, free part scarcely 2 lin. long, with a much longer foot. Mentum rounded, obtuse, 3 lin. long.

Roraima: Kotinga Valley, *McConnell & Quelch*, 137.—Endemic.

Allied to the Colombian *Maxillaria melina*, Lindl., but the leaves smaller, sheaths of the scape shorter, and with various differences in the structure of the flower.

MAXILLARIA QUELCHII, Rolfe, sp. n. Subcaulescens, vaginis imbricatis multistriatis. Pseudobulbi compressi, apice monophylli. Folia oblonga, subobtusa, conduplicata. Scapi foliis subæquales, vaginis lanceolatis subimbricatis obtecti. Bractea lanceolata, acuminata. Sepala oblongo-lanceolata, acuta. Petala lineari-lanceolata, acuta, sepalis breviora. Labellum trilobum, lobis lateralibus erectis rotundato-oblongis membranaceis, intermedio recurvo obovato-orbiculari obscure tricuspidato medio carnoso lateribus incurvo, callo oblongo obtuso concavo.

Subcaulescent, with the stems clothed with conduplicate, triangular-lanceolate, acute, closely striate, imbricating sheaths, 1–2 in. long, and partly enveloping the pseudobulbs. Pseudobulbs compressed, broadly oblong, shining and puncticulate, wrinkled when old, 1 in. long, $\frac{3}{4}$ in. broad, monophyllous at the apex. Leaves conduplicate, lanceolate-oblong, subobtuse, 3–4 in. long, $\frac{3}{4}$–1 in. broad. Scapes 3–4 in. long, bearing 5–7 lanceolate, acute, striate, somewhat imbricating sheaths, 6–12 lin. long. Bract resembling the sheaths, 10–12 lin. long. Sepals oblong-lanceolate, acuminate, $1\frac{1}{2}$ in. long. Petals linear-lanceolate, acuminate, $1\frac{1}{4}$ in. long. Lip $\frac{1}{2}$ in. long, 3-lobed; side lobes erect, rounded-oblong, membranaceous, 1 lin. long, $1\frac{1}{4}$ lin. broad; middle lobe recurved, obovate-orbicular, obscurely tricuspidate at the apex, 2 lin. broad by nearly as long, thickened along the centre and incurved at the sides; crest oblong, obtuse, concave. Column clavate, incurved, 3 lin. long.

Roraima, summit, at 8600 ft. alt., *McConnell & Quelch*, 690.—Endemic.

Allied to the Peruvian *M. floribunda*, Lindl., but much less scandent, and smaller in all its parts.

ONCIDIUM ORTHOSTATES, Ridl. in Trans. Linn. Soc. Ser. II. Bot. ii. (1887), p. 283.

Kwaimatta Savannah, *McConnell & Quelch*, 281. Ireng River, *im Thurn*, 12.—Also found at Mimatta, on the Rupununi River.

SOBRALIA STENOPHYLLA, Lindl. Fol. Orch., Sobral. p. 2; Ridl. in Trans. Linn. Soc. Ser. II. ii. (1887), p. 283.

Kotinga River, *McConnell & Quelch*, 147. Ireng Valley, *McConnell & Quelch*, 329. Ipelemouta, Arapu River, *im Thurn*, 19. Roraima, *Appun*, 1076.—Endemic.

EPISTEPHIUM LUCIDUM, Cogn. in Mart. Fl. Bras. iii. pt. IV. p. 141, t. 30.

Roraima, upper slopes, *McConnell & Quelch*, 32.—Also found in Brazil.

EPISTEPHIUM PARVIFLORUM, Lindl. Gen. & Sp. Orch. p. 433.

Kotinga Valley, *McConnell & Quelch*, 160.—Also found in Trinidad and elsewhere in British Guiana.

SPIRANTHES BIFIDA, Ridl. in Trans. Linn. Soc. Ser. II. Bot. ii. (1887), p. 283.

Kotinga Valley, *McConnell & Quelch*, 200. Roraima, summit, 8600 ft. alt., *McConnell & Quelch*, 692. South side at 5500 ft., *im Thurn*, 342.—Endemic.

POGONIA PARVIFLORA, Reichb. f. Xen. Orch. ii. p. 90; Ridl. in Trans. Linn. Soc. Ser. II. Bot. ii. (1887), p. 283.

Roraima, upper slopes, *McConnell & Quelch*, 30. "Flowers pink and waxy." South side at 5500 ft., *im Thurn*, 115.—Endemic.

POGONIA TENUIS, Reichb. f. in Griseb. Fl. Brit. W. Ind. p. 637.

Roraima, summit, 8600 ft., *McConnell & Quelch*, 691.—Also found in Trinidad, Venezuela, and on the Upper Amazon.

HABENARIA MORITZII, Ridl. in Trans. Linn. Soc. Ser. II. Bot. ii. (1887), p. 284.

Roraima, upper slopes, *McConnell & Quelch*, 4; at 4000 ft., *im Thurn*, 367.—Also found in Venezuela.

HABENARIA RORAIMENSIS, Rolfe, sp. n. Planta erecta, foliosa. Folia caulina, basi lanceolata, acuta, superiora gradatim in vaginas bracteiformes decrescentia. Bracteæ lanceolatæ, acuminatæ. Sepalum posticum erectum, ovatum, apiculatum; sepala lateralia patentia, oblique ovato-oblonga, apiculata. Petala bipartita, lobo postico falcato-oblongo apiculato, antico filiformi-lineari arcuato. Labellum tripartitum; lobi laterales filiformi-lineares divergentes; lobus intermedius linearis obtusus; calcar clavatum.

Plant ½–1¼ ft. high, somewhat leafy. Leaves cauline, the lower lanceolate, acute, 2–2½ lin. long, 4–5 lin. broad; upper smaller, decreasing upwards into bract-like sheaths. Bracts lanceolate, acuminate, 6–9 lin. long. Dorsal sepal erect, ovate, apiculate, 2–2½ lin. long, lateral spreading obliquely, ovate-oblong, apiculate, 2–2½ lin. long. Petals bipartite; upper lobe falcate-oblong, apiculate, 1½–2 lin. long; lower lobe filiform-linear, curved, shorter than the upper. Lip tripartite; side-lobes filiform-linear, diverging, 1½–2 lin. long; front lobe linear, obtuse, 2–2½ lin. long; spur linear-clavate, 4–5 lin. long. Anther-channels and stigmatic processes short.

Roraima, summit, 8600 ft., *McConnell & Quelch*, 698.—Endemic.

Allied to *H. pratensis*, Reichb. f., but readily distinguished by its much smaller flowers.

PHRAGMIPEDIUM KLOTZSCHIANUM, Rolfe, in Orch. Rev. iv. (1896), p. 332.

Cypripedium Klotzschianum, Reichb. f. in Linnæa, xxii. (1849), p. 811; Appun, Unter den Tropen, ii. p. 196.

Selenipedium Klotzschianum, Reichb. f. in Bonplandia, ii. (1854), p. 116; Ridl. in Trans. Linn. Soc. Ser. II. Bot. ii. (1887), p. 284.

Cypripedium Schomburgkianum, Klotzsch, in R. Schomb. Reisen in Brit.-Guiana, ii. p. 229; R. Schomb. Bot. Rem. Brit. Guiana, p. 59.

Arabapu River, *McConnell & Quelch*, 144. Aroie Creek, Kotinga River, *im Thurn*, 5. Ipelemouta, Arapu River, *im Thurn*, 31. Kako River, *Appun*, 1212.—Endemic.

BROMELIACEÆ.

BROCCHINIA REDUCTA, Baker, in Journ. of Bot. xx. (1882), p. 331; Baker, Handb. Brom. p. 88; Mez, in DC. Monog. Phan. ix. p. 341. (Plate 12.)

Roraima Range, 3500 ft., *McConnell & Quelch*, 702.—Also found on the Kaieteur Savannah, *Jenman*, 873.

PUYA FLOCCOSA, E. Morren, in Belg. Hort. xxxv. (1878), p. 81; Mez, in DC. Monog. Phan. ix. p. 478.

P. guianensis, Klotzsch, in R. Schomb. Reisen in Brit.-Guiana, iii. p. 1067.

P. sp., Baker, in Trans. Linn. Soc. Ser. II. Bot. ii. (1887), p. 285.

Roraima Range, 3500 ft., *McConnell & Quelch*, 701.—Also in Venezuela, Colombia, and Bolivia.

CONNELLIA, N. E. Brown, gen. nov.

Flores hermaphroditi, regulares. Sepala libera, oblonga. Petala libera, lata, basi angustata, nuda, sepalis multo longiora. Stamina petalis breviora et iis basi breviter adnata, filamentis filiformibus, antheris oblongis basifixis. Ovarium superum, trigonum, loculis multiovulatis; stylus elongatus; stigmata linearia. Capsula in carpellis 3 septicide separata, carpellis introrsum dehiscentibus. Semina numerosa, parva, linearia, utrinque appendiculata.—Herbæ habitu *Tillandsiæ*. Folia rosulata, integra vel basi denticulata. Inflorescentia terminalis, spiciformis, simplex vel composita. Flores sub quaque bractea solitarii vel plures, pedicellati.

CONNELLIA AUGUSTÆ, N. E. Brown. (Plate 13.) Capsula 6–7 lin. longa, 3 lin. diam., trigona, oblonga, coriacea, glabra, in carpellis 3 septicide soluta, carpellis longe rostratis introrsum dehiscentibus. Semina $1\frac{3}{4}$–2 lin. longa, lineari-teretia, curvata, utrinque membranaceo-appendiculata.—*Encholirium Augustæ*, R. H. Schomb. in Verh. des Ver. Beförd. Gartenb. in Preuss. (1846), p. 18, t. 2; in Bot. Zeitung (1846), p. 454; R. Schomb. Reisen in Brit.-Guiana, ii. p. 271, and iii. p. 1067; & in Bot. Rem. Brit. Guiana, p. 77; De Beer, Brom. p. 27. *Caraguata Augustæ*, Benth. & Hook. f. Gen. Pl. iii. p. 668. *Dyckia Augustæ*, Baker, Handb. Brom. p. 135. *Puya Augustæ*, Mez, in DC. Monogr. Phan. ix. p. 487, partim.

Summit of Mount Roraima, 8600 ft., *McConnell & Quelch*, 670. South slopes of Roraima at 6500 ft., *Schomburgk*, 687, 1021.

The discovery of fruiting specimens of this plant by Messrs. McConnell & Quelch demonstrates that it cannot properly be referred to either of the genera under which it has previously been placed. From *Encholirion* it differs totally in habit, large bracts, broad petals, and seeds. From *Caraguata* it differs in its free petals and in its seeds. From *Dyckia* it differs in habit, in the long-beaked entire (not bifid) carpels into which the ripe fruit separates, and in its seeds. And from *Puya* it differs in habit, in the petals not twisting when the flower fades, in the capsule not dehiscing loculicidally, and in the seeds. The only genus which approaches it in structure is *Lindmania*, Mez, but the habit, branching panicle, small bracts and very small flowers of the species of *Lindmania* are so entirely different from those of *Connellia*, that they cannot naturally be placed in the same genus. Possibly the fruit of *Lindmania*, which I have not seen, and the dorsifixed anthers may afford technical characters to distinguish the two genera, especially if taken in conjunction with the difference in habit.

CONNELLIA QUELCHII, N. E. Brown. (Plate 14.) Folia rosulata 1½–5¾ poll. longa, angusta, convoluta, integra, basi tantum minute denticulata, supra tomentosa, subtus glabra, vel rare utrinque tomentosa, marginibus albo-tomentosis. Scapus simplex, multibracteatus. Bracteæ imbricatæ, glabræ, nitidæ; inferiores steriles amplexicaules, abrupte subulato-cuspidatæ; florigeræ elliptico-ovatæ, apiculatæ, valde concavæ. Flores sub quaque bractea solitarii, pedicellati, speciosi, rosei.—*Tillandsia stricta*, var.?, Baker, in Trans. Linn. Soc. Ser. II. Bot. ii. (1887), p. 285. *Puya Augustæ*, Mez, in DC. Monog. Phan. ix. p. 487, partim.

Leaves rosulate, 1½–5¾ in. long, 2–4½ lin. broad, linear, convolute-subulate, rather blunt, rigidly coriaceous, minutely denticulate at the base only, densely white-tomentose on the inner face and along the margins, usually glabrous on the convex back, rarely tomentose on both sides. Scape arising from the centre of the rosette, 2–5 in. long to the lowest flower of the 2–3½ in. long raceme, 1–1½ lin. thick, glabrous, clothed with imbricating bracts, which are ⅔–1¼ in. long, 6–8 lin. broad, stem-clasping, broadly elliptic-oblong and abruptly contracted into a subulate leafy point at the apex, or broadly ovate and simply acute or acuminate, glabrous, with tomentose margins to the leafy point, brown in the dried state, shining. Raceme moderately dense, 1¼–1¾ in. diam., 7–13-flowered, its bracts ascending or somewhat spreading, 7–10 lin. long, 5–7 lin. broad, elliptic-ovate, acute or obtuse and apiculate, deeply concave, glabrous, brown, shining. Flowers solitary under each bract, pedicellate. Pedicels 2–8 lin. long, glabrous. Sepals free, 5–5½ lin. long, 2½–3 lin. broad, ovate-oblong, acute, glabrous, light brown, with thin rose-pink margins. Petals free, 9 lin. long, 5½ lin. broad, orbicular, obtuse, narrowed into a short broad claw at the base, glabrous, entire, without a scale at their base, bright rose-pink. Stamens about 5 lin. long, glabrous; filaments very shortly adnate to the petals at their base, filiform; anthers ¾ lin. long, oblong, obtuse. Ovary superior, trigonous-ovoid, glabrous, narrowed into a glabrous style 3½ lin. long, with 3 recurving compressed linear stigmas about 1 lin. long, slightly undulated along the stigmatose surface.

Summit of Mount Roraima, 8600 ft., *im Thurn*, 315; *McConnell & Quelch*, 107, 672.

In general appearance this plant bears a slight resemblance to *Tillandsia stricta*, Soland., but in all details is very different. It is considered by Mez to be identical with *C. Augustæ*; but although an undoubted congener of that plant, is most certainly very distinct from it specifically, being very much smaller in size, with the upper surface and margins of the leaves tomentose, solitary flowers under each bract, and a glabrous calyx; whilst *C. Augustæ* has leaves 8–14 in. long, quite glabrous on both sides, the flowers are in clusters of 3–7 under each bract, and the calyx is thinly covered with short hairs. I have not seen ripe seeds of *C. Quelchii*, but the ovules show that they will be appendaged at each end It is a very pretty species and well worth cultivating.

Tillandsia rhodocincta, Baker, in Journ. Bot. xxvi. (1888), p. 143, & Handb. Brom. p. 178; Mez, in DC. Monog. Phan. ix. p. 791. *Tillandsia sp.*, Baker, in Trans. Linn. Soc. Ser. II. Bot. ii. (1887), p. 285.

Summit of Mount Roraima, *McConnell & Quelch*, 671.—Endemic.

IRIDACEÆ.

Sisyrhinchium alatum, Hooker, Icones Plant. t. 219, var.

Kotinga Valley, *McConnell & Quelch*, 139.

LILIACEÆ.

Nietneria corymbosa, Klotzsch, in R. Schomb. Reisen in Brit.-Guiana, iii. p. 1066; im Thurn & Oliver, in Trans. Linn. Soc. Ser. II. Bot. ii. (1887), pp. 269, 285.

Upper slopes of Mount Roraima, *McConnell & Quelch*, 12, 36, 328. Summit of Mount Roraima, *McConnell & Quelch*, 83, 656.—Apparently endemic to the region.

Tofieldia Schomburgkiana, Oliver, in Trans. Linn. Soc. Ser. II. Bot. ii. (1887), p. 285, t. 49. f. A.

Isidrogalvis guianensis, Klotzsch, in R. Schomb. Reisen in Brit.-Guiana, iii. p. 1065, name only.

Upper slopes and summit of Mount Roraima, *McConnell & Quelch*, 93, 326, 657; *Schomburgk*.—Endemic.

XYRIDACEÆ.

Xyris Seubertii, Nilss. in K. Svensk Akad. Handl. xxiv. (1892), No. xiv. p. 51, t. 4. f. 1.

Upper slopes of Mount Roraima, *McConnell & Quelch*, 41.—The locality in which Schomburgk collected this plant is unknown to me, and the leaves of his specimens are much smaller than those of the specimens collected by McConnell & Quelch.

Xyris concinna, N. E. Brown, sp. n. Planta 3–6 poll. alta, perennis, glabra. Caudex ¼–½ poll. longus. Folia disticha, 1–2¾ poll. longa, anguste linearia, acuta. Pedunculus subteres, uno margine prominente, basi vagina apice breviter foliata instructus. Spica ovoidea. Bracteæ oblongæ vel ellipticæ, obtusæ, castaneæ, late albo-marginatæ, laceratæ, glabræ. Sepala lateralia lineari-lanceolata, acuta, carinata, glabra, carina integra vel ad medium minutissime scabrida. Petala elliptica, obtusa, integra, lutea. Staminodia bibrachiata, brachiis penicillatis luteis.

Perennial. Caudex ¼–½ in. (or more?) long, ½ lin. thick, naked below the leaves, emitting fibrous roots. Leaves distichous, 1–2¾ in. long, ⅓–⅔ lin. broad, linear, acute, abruptly dilated into a short, broad, bright brown, clasping base, not twisted, glabrous. Peduncles 1–6 to a stem, 2½–5½ in. long, ¼–⅓ lin. thick, subterete, with a raised line along one side, glabrous; their basal sheaths ¾–1¾ in. long, produced at the apex into a short compressed or leafy point, keeled, glabrous, often minutely ciliate along the keel or at its apex. Spikes 2½–3½ lin. long, ovoid, obtuse. Bracts 1½–2½ lin. long, 1–1½ lin.

broad, oblong or elliptic, obtuse, chestnut-brown, with a broad white hyaline border, which soon becomes lacerated, glabrous. Lateral sepals 2¾ lin. long, ½ lin. broad, complicate, linear-lanceolate, acute, keeled, yellowish-brown, glabrous, the keel quite entire or very minutely scabrid along the middle. Petals 2 lin. long, 1 lin. broad, elliptic, obtuse, entire, yellow. Staminodes 2-armed, about ½ lin. long, divided into tufts of yellow hairs.

Summit of Mount Roraima, 8600 ft., *McConnell & Quelch*, 496.

Allied to *Xyris Seubertii*, Nilss., but distinguished by its smaller size, lacerated bracts, and the glabrous or very minutely scabrid keel of the lateral sepals. The broad bright brown bases of the leaves give the base of the plant a somewhat bulbous appearance.

Xyris witsenioides, Oliver, in Trans. Linn. Soc. Ser. II. Bot. ii. (1887), p. 285, t. 50. f. B.

X. caulescens, Klotzsch, in R. Schomb. Reisen in Brit.-Guiana, iii. p. 1064, name only.

Summit of Mount Roraima, *McConnell & Quelch*, 95, 658.—Endemic.

Abolboda Sceptrum, Oliver, in Trans. Linn. Soc. Ser. II. Bot. ii. (1887), p. 286, & pp. 258, 259, 262, 267, & 268.

Summit of Mount Roraima, *McConnell & Quelch*, 668.—Endemic on Roraima and the surrounding region.

The specimen collected by McConnell & Quelch consists of adult leaves and young plants, and that collected by im Thurn of the upper part of a flowering stem without leaves, so that this interesting plant is as yet very imperfectly represented in European Herbaria.

RAPATEACEÆ.

Stegolepis guianensis, Klotzsch, *ex* Koern. in Linnæa, xxxvii. (1871–73), p. 481; im Thurn & Oliver, in Trans. Linn. Soc. Ser. II. Bot. ii. (1887), pp. 265, 267 & 286.

Summit of Mount Roraima, *McConnell & Quelch*, 669.—Endemic.

ERIOCAULACEÆ.

Eriocaulon tenuifolium, Klotzsch, in R. Schomb. Reisen in Brit.-Guiana, iii. p. 1116.

Savannahs generally, *McConnell & Quelch*, 307.

Pæpalanthus Roraimæ, Oliver, in Trans. Linn. Soc. Ser. II. Bot. ii. (1887), p. 286.

Summit of Mount Roraima, *McConnell & Quelch*, 102, 315, 660.—Endemic.

Pæpalanthus flavescens, Koern. in. Mart. Fl. Bras. iii. pt. i. p. 423; im Thurn & Oliver, in Trans. Linn. Soc. Ser. II. Bot. ii. (1887), pp. 263, 286.

P. eriocephalus, Klotzsch in R. Schomb. Reisen in Brit.-Guiana, iii. p. 1064, name only.

Upper slopes of Mount Roraima, *McConnell & Quelch*, 9, 10, 327.—Also in Venezuela and Brazil.

Pæpalanthus fraternus, N. E. Brown, sp. n. Acaulis. Folia dense rosulata, linearia, subacuta, basi late dilatata, supra canaliculata, rigida, supra pilis articulatis appressis tenuiter obtecta et pilis longis paucis laxe ciliata, subtus vel rare utrinque glabra, in axillis dense lanato-villosa. Pedunculi 8–12 poll. longi, laxe villosi, rare glabri. Capitula $4\frac{1}{2}$–5 lin. diam., albo-villosa. Bracteæ involucrantes 3–4-seriatæ, late ovatæ, acutæ, dorso appresse pubescentes, fuscæ. Bracteæ inter flores oblongæ, subacutæ, apice dense albo-barbatæ. Receptaculum pilosum. Sepala elliptica, obtusa, hyalino-olivacea, ciliata, apice dense albo-barbata. Petala floris masculini in tubum infundibuliformem stipitatum connata; floris fœminei libera, sessilia, anguste linearia, dense ciliato-barbata.

A stemless perennial. Leaves densely rosulate, 1–$1\frac{3}{4}$ in. long, 1–$1\frac{1}{2}$ lin. broad, linear, tapering to a blunt point, rather abruptly dilated into a broad open sheath at the base, rigid, concave and thinly covered with adpressed white jointed hairs on the face, convex and glabrous on the back, rarely glabrous on both sides, veins not prominent, scarcely striate, often, but not always, thinly ciliate with a few long hairs, densely villose-woolly with long fine hairs in the axils. Peduncles 1–3 to a plant, 8–12 in. long, slender, obscurely 6–7-angular, thinly covered with short spreading hairs or rarely glabrous; their basal sheaths 1–$1\frac{3}{4}$ in. long, with a rigid oblique subacute ciliate mouth, otherwise glabrous. Heads $4\frac{1}{2}$–5 lin. diam., at first hemispherical, afterwards globose, monœcious or rarely unisexual. Involucral bracts in 3–4 series, the innermost $1\frac{3}{4}$–2 lin. long, $1\frac{1}{2}$ lin. broad, broadly ovate, acute, fuscous, adpressed-pubescent on the back, ciliate, the outer gradually smaller. Flowering-bracts $1\frac{1}{2}$ lin. long, $\frac{1}{2}$ lin. broad, oblong, obtuse or subacute, pale fuscous, densely bearded with white hairs on the apical part. Receptacle pilose with long white hairs, as are also the pedicels of the flowers. Male flowers pedicellate; sepals 3, $1\frac{1}{4}$ lin. long, $\frac{1}{2}$ lin. broad, elliptic, obtuse or subacute, fuscous, densely bearded with white hairs on the apical part; petals arising $\frac{1}{2}$ lin. above the sepals, all united into a hyaline funnel-shaped tube $\frac{1}{2}$ lin. long, truncate, with 3 very minute teeth at the apex, glabrous; stamens shortly exserted, with white anthers; rudimentary pistil represented by 3 clavate bodies, minutely papillate at the apex. Female flowers shortly pedicellate; sepals $1\frac{1}{2}$ lin. long, $\frac{2}{3}$–$\frac{3}{4}$ lin. broad, elliptic, subacute, beautifully reticulated with fuscous, ciliate from the base and densely bearded on the upper half with long white hairs; petals 3, free, arising close to the sepals, 1 lin. long, about $\frac{1}{6}$ lin. broad, ciliate and clothed on both sides with long white hairs; ovary ovoid, trigonous, glabrous, narrowed into a style about $\frac{1}{3}$ lin. long, with 3 linear bifid stigmas, and 3 stout appendages, papillate at the apex only.

Summit of Mount Roraima, 8600 ft., *McConnell & Quelch*, 96, 659.

Allied to *P. falcatus*, Koern., and *P. flavescens*, Koern. From the former it differs by its more rigid, channelled leaves, less woolly heads, and more acute involucral bracts, and from *P. flavescens*, Koern., by the narrower and more acute leaves, which have a different pubescence, and the very different flower-heads. It also appears to be near *P. Schomburgkii*, Klotzsch (which I have not seen), but that plant is described as having longer and broader leaves, striate, with prominent veins on the upper side, a subulate point to the peduncular sheath, much shorter peduncles. and glabrous involucral bracts.

PÆPALANTHUS SUBCAULESCENS, N. E. Brown, sp. n. Planta 4–8 poll. alta. Caulis simplex, dense foliosus. Folia lineari-lanceolata, acuta, glabra, juniora pilis longis laxe ciliata. Pedunculi 2–7-aggregati, obtuse 4-angulati, glabri, vaginis oblique fissis apice subulato-apiculatis glabris ore ciliatis. Capitula hemisphærica, albo-villosa. Bracteæ involucrantes suborbiculares vel late obovatæ, obtusissimæ, minutæ ciliatæ, fuscæ. Bracteæ inter flores oblongæ, obtusæ, apiculatæ, apice albo-barbatæ. Receptaculum glabrum, sed pedicellis laxe pilosis. Floris masculi sepala obovata, obtusa, apice albo-barbata; petala in tubum tridentatum longe stipitatum connata. Floris fœminei sepala elliptica vel obovata, obtusa, apice albo-barbata; petala libera, oblonga, obtusa, pilis longis dense ciliata, dorso glabra.

A perennial, with a simple densely leafy stem ½–2½ in. long. Leaves ¾–1½ in. long, 1–2½ lin. broad, linear-lanceolate, acute, glabrous, striate, green, the younger laxly ciliate with long white hairs, ascending, becoming deflexed with age. Peduncles 2–7 to a plant, 2½–5½ in. long, slender, obtusely 4-angled, glabrous; their basal sheaths 1–1¼ in. long, glabrous, with an oblique ciliate mouth, acute or subulate-pointed. Heads 2–3 lin. diam., hemispherical, monœcious, white-villous. Involucral bracts in 3–4 series; the innermost ¾ lin. long, ¾–1 lin. broad, suborbicular or broadly obovate, very obtuse, glabrous, minutely ciliate, fuscous, the outer gradually smaller. Flowering bracts ¾–1 lin. long, ½ lin. broad, oblong, obtuse, apiculate, fuscous, densely bearded with short white hairs on the apical part. Receptacle apparently glabrous, but with the base of the pedicels pilose with long hairs. Male flowers: sepals ¾ lin. long, ⅓ lin. broad, obovate, obtuse, brown, bearded with white hairs at the apex; petals connate into a hyaline, subtruncate, minutely 3-toothed tube, separated from the sepals by a stipes nearly ½ lin. long, glabrous; anthers white. Female flowers: sepals ¾–1 lin. long, nearly ½ lin. broad, elliptic or obovate, obtuse, fuscous or brownish, densely bearded with short white hairs on the apical part; petals 3, free, arising close to the sepals, ¾ lin. long, ⅓ lin. broad, oblong, obtuse, light fuscous, densely fringed with very long hairs on the margins and borders of the inner face, glabrous on the back; ovary glabrous, trigonous; style elongated; stigmas linear, bifid to halfway down; appendages rather thick, papillate at the apex.

Kotinga Valley, *McConnell & Quelch*, 153. Savannahs generally, *McConnell & Quelch*, 300.

A very distinct species, bearing a resemblance to *P. uncinatus*, Gardn., in stem and foliage, but with very different flower-heads. It might be placed near *P. plantagineus*, Koern.

PÆPALANTHUS BIFORMIS, N. E. Brown, sp. n. Planta pusilla, acaulis, ut videtur annua. Folia rosulata, 3–4 lin. longa, linearia, acuta, supra arachnoideo-tomentosa, demum glabra. Pedunculi 3–4, filiformes, 1¾–2¼ poll. longi, laxe villosi vel subglabri, vaginis glabris ore obliquis acutis. Capitula hemisphærica, 2–2½ lin. diam., pallide luteo-alba. Bracteæ involucrantes oblongæ vel ovato-oblongæ, acutæ, glabræ. Bracteæ inter flores nullæ. Receptaculum et pedicelli lanati. Flores masculi quam fœminei multo minores, oblique deltoidei, acuti, sepalis inæqualibus ad medium barbatis, petalis in tubum minutum stipitatum connatis. Flores fœminei recti; sepala eorum 3, libera, anguste lanceolata, acuminata, carinata, glabra, ad medium ciliata; petala 3, cuneato-obovata, prope apicem obtusum incurvum leviter connata, dorso pilis longis dense vestita.

A small stemless annual? Leaves rosulate, very spreading, 3–4 lin. long, $\frac{1}{4}$–$\frac{1}{2}$ lin. broad, linear, acute, thinly cobwebby-tomentose above, becoming glabrous, glabrous beneath, woolly in the axils. Peduncles 3–4 to a plant, $1\frac{3}{4}$–$2\frac{1}{4}$ in. long, filiform, thinly villose or nearly glabrous. Heads simple, monœcious, 2–$2\frac{1}{2}$ lin. diam., very pale straw-coloured in all parts. Involucral-bracts in 3–4 series, much shorter than the flowers, the innermost $\frac{3}{4}$ lin. long, $\frac{1}{4}$–$\frac{1}{3}$ lin. broad, oblong or ovate-oblong, acute, quite glabrous, thin, semi-transparent. Flowering-bracts none. Receptacle and pedicels very woolly. Male flowers much smaller than the female flowers, with rather longer pedicels, very oblique; sepals 3, two of them $\frac{1}{2}$ lin. long, $\frac{1}{4}$ lin. broad, obliquely semiovate, straight along one margin, very much curved along the other, acute, the third smaller, rhomboid-lanceolate, acute, all bearded with short hairs at about the middle, transparent; petals connate into a very minute, stipitate, funnel-shaped cup, glabrous; anthers white. Female flowers straight, projecting much beyond the males; sepals 3, free, 1 lin. long, $\frac{1}{4}$ lin. broad, narrowly lanceolate, acuminate, boat-shaped, keeled, glabrous, ciliate at the middle only, transparent; petals arising a little above the sepals, scarcely $\frac{1}{2}$ lin. long, about $\frac{1}{8}$ lin. broad, cuneate-obovate, obtuse and inflexed at the apex, and apparently slightly connate there, densely clothed with long hairs on the back; ovary trigonous, glabrous, with a glabrous style, divided at the apex into 3 simple stigmas and 3 slender clavate appendages. Capsule scarcely $\frac{1}{4}$ lin. diam. Seeds ellipsoidal, faintly ribbed, glabrous, brown.

Kotinga Valley, near Mount Roraima, *McConnell & Quelch*, 126.

This species much resembles *Pæpalanthus simplex*, Miq., but is readily distinguished by the very unequal size and dissimilar form of the male and female flowers, the females conspicuously projecting much beyond the males, so that the heads have a somewhat echinate appearance.

PÆPALANTHUS UMBELLATUS, Kunth, Enum. Pl. iii. p. 537.
Kotinga Valley, *McConnell & Quelch*, 129.

PÆPALANTHUS SUBTILIS, Miq. Stirp Surin. Sel. p. 221.
Savannahs generally, *McConnell & Quelch*, 312.

PÆPALANTHUS CAPILLACEUS, Klotzsch, in R. Schomb. Reisen in Brit.-Guiana, i. p. 377, ii. p. 5, & iii. p. 1063; Koern. in Mart. Fl. Bras. iii. pt. I. p. 415, t. 53. f. 2.

Kukenaam River, *McConnell & Quelch*, 314. Roraima, *Appun*, 1217.—Endemic to the region.

CYPERACEÆ.

CYPERUS UNCINATUS, Poir. Encycl. vii. p. 247.

Kotinga Valley near Roraima, *McConnell & Quelch*, 128. Savannahs generally, *McConnell & Quelch*, 321.

Fuirena umbellata, Rottb. Descr. et Ic. Pl. p. 70, t. 19. f. 3.
Ireng Valley, *McConnell & Quelch*, 254.

Hypolytrum pungens, Vahl, Enum. ii. p. 283.
Kotinga Valley, *McConnell & Quelch*, 179.

17432 **Everardia angusta**, N. E. Brown, sp. n. Folia linearia, acuta, laxe pilosa. Culmi basi vaginati, aphylli, valde compressi, leviter concavo-convexi, parce pilosi vel fere glabri. Panicula elongata, linearia, stricta, ramis gracilibus erectis 1- (rare 2-)spiculatis in axillis vaginorum aggregatis. Spiculæ masculæ lanceolatæ, glumis 5–7 coraceis oblongis acutis mucronatis brunneis sterilibus et glumis 4–6 membranaceis oblongis obtusis fertilibus instructæ; stamina sub quaque gluma 6–12. Spiculæ fœmineæ omnes ad apicem paniculi dispositæ, glumis 5 oblongo-lanceolatis acutis mucronatis ovarium solitarium stipitatum circumdatis; stigmata 3, dense villosa; pili hypogyni copiosi.

Leaves in tufts of 3–6, distinct from the flowering culms, 8–12 in. long, $1\frac{1}{4}$–$1\frac{2}{3}$ lin. broad, linear, acute, often folded, but when expanded channelled down the face, with an acute ridge on each side of the channel, flat on the back, thinly pilose, usually slightly recurving. Flowering culms 14–18 in. high, including the panicle, $\frac{1}{2}$–$\frac{3}{4}$ lin. broad, flattened, slightly concave on one side, convex on the other, sparingly pilose or nearly glabrous, produced on distinct leafless shoots, embraced by a long glabrous leafless sheath at the base. Panicle 7–12 in. long, strictly erect, linear, composed of 4–5 distant tufts of erect, simple or once umbellately divided, filiform branchlets, clustered in the axils of close-fitting brown sheaths $\frac{1}{3}$–$\frac{3}{4}$ in. long, which have spreading leafy points $\frac{1}{2}$–1 in. long. Spikelets solitary or very rarely 2 at the end of the branchlets, light brown. Male spikelets 3-4 lin. long, 1–$1\frac{1}{4}$ lin. thick, lanceolate, with 5–7 coriaceous, oblong, acute, mucronate, brown empty glumes, thinly and minutely pubescent on the back, and 4–6 membranous, oblong, obtuse, fertile glumes; stamens 6–12 under each glume; anthers 2 lin. long, linear, tipped with a minute tuft of stiff hairs. Female spikelets all at the apex of the panicle, more slender than the males, 3 lin. long, about $\frac{2}{3}$ lin. thick, with about 5 oblong-lanceolate, acute, mucronate, minutely ciliate glumes surrounding the solitary pubescent ovary; stigmas 3, densely villose; hypogynous hairs copious.

Summit of Mount Roraima, 8600 ft., *McConnell & Quelch*, 676.

This species is easily distinguished from the following by its very much narrower leaves and less floriferous panicles.

Everardia montana, Ridl. in Trans. Linn. Soc. Ser. II. Bot. ii. (1887), p. 287.
Summit of Mount Roraima, *McConnell & Quelch*, 674.—Endemic.

GRAMINEÆ. F19

17433 **Panicum eligulatum**, N. E. Brown, sp. n. Folia erecta, linearia, attenuato-acuta, rigida, cinereo-glauca, supra ad basin longe villosa et ad basi vaginorum villoso-tomentosa; ligula nulla. Culmi 10–13 poll. longi, stricti, striati, glabri, ad nodos

subglauci, bivaginati, vagina inferiore foliosa. Panicula 2–3 poll. longa, oblonga, multiflora. Spiculæ ellipsoideæ, 1–2-floræ. Glumæ 3 inferiores vacuæ, glabræ, brunneæ vel atro-fuscæ ; gluma infima parva ; secunda et tertia subæquales ellipticæ, obtusæ, profunde concavæ 6–7-nerves. Gluma florens elliptica, obtusa, profunde concava, lævis, 5-nervis, glabra, albida. Palea elliptica, obtusa, concava, 2-nervis, glabra, albida.

Leaves, excluding the sheaths, 6–9 in. long, $2\frac{1}{2}$–3 lin. broad, linear, tapering to a very acute subpungent point, with involute margins, rigid, erect, greyish-glaucous, striate, more or less densely pilose on the upper side at the base, and densely villose-tomentose at the very base of the sheaths ; ligule none. Culms 10–13 in. long, straight, striate, glabrous, more or less glaucous at the nodes, bearing two sheaths, the lower of which bears a short leaf. Panicle 2–3 in. long, $\frac{3}{4}$–1 in. diam., oblong-lanceolate, moderately compact, with semiverticillate, erect, glabrous branchlets and pedicels. Spikelets $1\frac{1}{4}$–$1\frac{1}{2}$ lin. long, ellipsoidal, 1–2-flowered. Empty glumes 3, glabrous, brown or blackish ; the lowest $\frac{3}{4}$–1 lin. long, $\frac{1}{3}$ lin. broad, oblong or elliptic-oblong, obtuse, 2-nerved ; the 2 inner $1\frac{1}{4}$ lin. long, $\frac{1}{2}$ lin. broad, elliptic, obtuse, deeply boat-shaped, 6–7-nerved. Flowering glume 1 lin. long, elliptic, obtuse, deeply concave, 5-nerved, glabrous, smooth, whitish. Pale similar to the flowering glume, but smaller and flatter, 2-nerved, whitish. Anthers $\frac{3}{4}$ lin. long, very dark purplish brown. Stigmas 2, densely plumose, brown or fuscous.

Summit of Mount Roraima, 8600 ft., *McConnell & Quelch*, 675.

Allied to *Panicum loreum*, Trin., but the leaves and panicle are shorter than they are in that species, the spikelets rather larger, and the leaves quite destitute of a ligule, the absence of which is its most remarkable character, since there are few grasses in which all trace of a ligule is absolutely wanting.

PANICUM CHNOODES, Trin. Gram. Panic. p. 211.

Roraima Range, 3500 ft., *McConnell & Quelch*, 709.—Also in Brazil.

ECHINOLÆNA HIRTA, Desv. Journ. Bot. i. (1813), p. 75.

E. scabra, H. B. & K. Nov. Gen. & Sp. i. p. 118, t. 38 ; Oliver, in Trans. Linn. Soc. Ser. II. Bot. ii. (1887), p. 288.

Upper slopes of Mount Roraima, *McConnell & Quelch*, 74.—Throughout Guiana and Brazil. The only other species of this genus is a native of Madagascar.

OLYRA MICRANTHA, H. B. & K. Nov. Gen. & Sp. i. p. 199.

Roraima Range, 3500 ft., *McConnell & Quelch*, 708.—Widely dispersed in Brazil and Guiana.

1020 ARUNDO RORAIMENSIS, N. E. Brown, sp. n. Planta $\frac{1}{2}$–3 ped. alta, culmo ad apicem laxe folioso glabro. Folia linearia, complicata, apice oblique subacuta, subrigida, glabra vel minutissime scaberula, rare supra ligulam laxe pilosa, intra microscopice papillosa ; ligula ad annulum dense pilosum reducta. Panicula 4–6 poll. longa, ramis pedicellisque scaberulis vel villosis. Spiculæ 3–5-floræ, rhachilla breviter pilosa inter flores articulata. Glumæ 2 inferiores vacuæ, subæquales, lineares, acutæ vel minute

trifidæ, 1-nerves, submembranaceæ, glabræ; glumæ florentes oblongæ, longe aristatæ, basi longe pilosæ, 5-nerves. Palea lineari-oblonga, bifida vel emarginata, 2-nervis, membranacea, marginibus inflexis.

Perennial, $1\frac{1}{2}$–3 ft. (or more?) high. Stems laxly leafy to the top, glabrous. Lower leaves 9–20 in. long, the upper gradually shorter, $1\frac{1}{2}$–3 lin. broad, erect, slightly rigid, linear, complicate, very obliquely subacute, glabrous or occasionally very minutely and thinly scaberulous on the back, microscopically papillate on the upperside, sometimes pilose and ciliate with long hairs just above the ligule, which is reduced to a dense ring of hairs. Panicle slightly nodding, 4–6 in. long, $1\frac{1}{2}$–$2\frac{1}{2}$ in. broad, not very dense, its branches and pedicels scaberulous or villose. Spikelets 8–9 lin. long, 3–5-flowered, the rhachilla readily disarticulating between the flowers, which are hermaphrodite. Empty glumes 2, subequal, 3–$3\frac{1}{2}$ lin. long, linear, acute and mucronate or shortly bifid at the apex, 1-nerved, membranous, glabrous. Flowering glume (excluding the awn) 3 lin. long, oblong-lanceolate, very concave, villose on the basal part with white hairs 2 lin. long, 5-nerved, trifid at the apex, with the middle tooth (or nerve) running out into a straight scabrid awn about 4 lin. long. Pale $2\frac{1}{2}$ lin. long, oblong-linear, with inflexed margins, bifid or emarginate at the apex, 2-nerved, scabrous on the nerves, otherwise glabrous. Lodicules $\frac{1}{4}$ lin. long, broad and oblique, subentire or crenately 2-lobulate, glabrous. Stamens 3. Ovary about 1 lin. long, slightly fusiform, or subterete, glabrous. Styles 2, plumose for $\frac{2}{3}$ of their length, yellow or brown.

Summit of Mount Roraima, 8600 ft., *McConnell & Quelch*, 673.

Allied to *A. pilosa*, D'Urv.

853b **Arundinaria deflexa**, N. E. Brown, sp. n. Culmi superne ramosi, ramis erectis teretibus glabris foliosis. Folia deflexa, lanceolata, acuminata, glabra, marginibus scaberulis; ligula brevis, subtruncata; vagina ad apicem longe setosa. Panicula terminalis, erecta, angusta, laxa, glabra. Spiculæ angustæ, paucifloræ. Glumæ inferiores 3 vacuæ, gluma extima minimus, 2 sequentes florentibus subsimiles sed minores; glumæ florentes ovato-lanceolatæ, obtusæ, concavæ, 7-nerves, glabræ, minutissime ciliatæ. Palea angusta, brevissime bifida, bicarinata, carinis ciliatis.

Stems branching in the upper part. Branches very erect, close to and parallel with the main stem, terete, glabrous, leafy, nearly concealed by the leaf-sheaths. Leaves deflexed, 5–$5\frac{1}{2}$ in. long, 9–11 lin. broad, lanceolate, tapering to a very acute point, glabrous on both sides, scabrid on the margins, probably slightly glaucous beneath; primary veins not very distinct from the rest; sheaths closely embracing the stem, glabrous, striate, with a fringe of long bristles at the apex; ligule short, subtruncate, glabrous. Panicle 5–11 in. long, 1–2 in. broad, lax, with slender erect glabrous branches. Spikelets about 3-flowered, 5–6 lin. long, narrow, with the 3 lower glumes empty, the lowest of which is about 1 lin. long, the second and third 2–$2\frac{1}{2}$ lin. long, oblong, obtuse, concave, glabrous, not ciliate, obscurely 5–7-nerved. Flowering glume $3\frac{1}{2}$–$3\frac{3}{4}$ lin. long, ovate-lanceolate, obtuse, concave, glabrous, very minutely ciliate, 7-nerved. Pale 3 lin. long, linear-oblong, with inflexed sides, slightly bifid at the obtuse apex, with 2 keel-like ciliate nerves. Anthers $1\frac{1}{2}$ lin. long, linear.

Summit of Mount Roraima, 8600 ft., *McConnell & Quelch*, 678.

The spikelets on the specimens seen are imperfect, most of them consisting of empty bracts only, and none that I have examined contain a perfect ovary.

Chusquea linearis, N. E. Brown, sp. n. Culmi graciles, internodiis $\frac{3}{4}$–$2\frac{1}{4}$ poll. longis, ramulis brevibus ad nodos aggregatis. Folia 6–10 lin. longa, 1–$1\frac{1}{2}$ lin. lata, lanceolata, acutissima, glabra, secus unum marginem minute scaberula; vaginæ striatæ, pubescentes, ligula brevi subtruncati. Racemi ad nodos aggregati, lineares, spiculis 3–6, unifloris. Glumæ inferiores 4 vacuæ, gluma infima minima, sequentes majores pubescentes; gluma florens convoluta, obtusa, apicem tantum pubescens, 7–8-nervis. Palea oblongo-ovata, obtusa, convoluta, glabra, apice ciliata, 4-nervis.

Stems slender, terete, glabrous, with internodes $\frac{3}{4}$–$2\frac{1}{4}$ in. long, concealed by the striated sheaths, bearing at the nodes clusters of 4–10 simple leafy or flowering branches $1\frac{1}{2}$–3 in. long. Leaves distichous, those on the branches $1\frac{1}{2}$–2 lin. distant, 6–10 lin. long, 1–$1\frac{1}{2}$ lin. broad, lanceolate, tapering to a very acute mucronate point, abruptly narrowed into a very short petiole at the base, glabrous, minutely ciliate-scabrid along one margin, striate beneath from the numerous closely placed prominent nerves; sheaths striate, pubescent; ligule short, subtruncate, no bristles. Racemes linear, with 3–6 pedicellate, adpressed, 1-flowered spikelets, or the terminal one with 14–15 spikelets. Outer 4 glumes empty; the lowest $\frac{1}{2}$–$\frac{3}{4}$ lin. long, broadly oblong, obtuse, 1-nerved; the second $1\frac{1}{4}$–$1\frac{3}{4}$ lin. long, oblong, obtuse, with or without a short awn, 1-nerved; the two others subequal, $2\frac{1}{2}$–$2\frac{3}{4}$ lin. long, oblong-lanceolate, acute, very concave, 5–6-nerved, all more or less pubescent on the back and ciliate, at least at the apex. Flowering glume $2\frac{3}{4}$ lin. long, ovate-lanceolate, obtuse, convolute, pubescent and ciliate at the apex only, with 7–8 slender nerves. Pale 2 lin. long, oblong-ovate, convolute, obtuse and ciliate at the apex, membranous, with 4 slender nerves. Lodicules 3, narrowly oblong, obtuse, ciliate at the apex, $\frac{2}{3}$–$\frac{3}{4}$ lin. long. Stamens 3; anthers 1 lin. long, linear. Ovary narrowly ovoid, glabrous; styles 2, narrowly plumose nearly to the base.

Summit of Mount Roraima, 8600 ft., *McConnell & Quelch*, 677.

Allied to *C. abietifolia*, Griseb., but among other characters is easily distinguished by its linear racemes.

II. PTERIDOPHYTA.

By C. H. Wright, A.L.S.

1. Gleichenia pubescens, H. B. & K. Nov. Gen. & Sp. i. p. 29. *Mertensia pubescens*, Willd.; R. Schomb. Reisen in Brit.-Guiana, ii. p. 272: Appun, Unter den Tropen, ii. p. 594.
Roraima range, 3500 ft., *McConnell & Quelch*, 610, 619.
British Guiana: Kwating Creek; also Mexico and West Indies to Chili.

2. Cyathea vestita, Mart. in Denkschr. Regensb. ii. (1822), p. 146. *C. hirtula*, Mart.; R. Schomb. Reisen in Brit.-Guiana, ii. p. 272; Appun, Unter den Tropen, ii. p. 594.
Roraima range, 3500 ft., *McConnell & Quelch*, 605.
Humirida Mountains, Brazil.

3. Hemitelia subincisa, Kunze, in Bot. Zeit. ii. (1844), p. 296.
Roraima range, 3500 ft., *McConnell & Quelch*, 620.
British Guiana: Kwating Creek; also Central and Tropical South America.

Alsophila marginalis, Klotzsch. in Linnæa, xviii. (1844), p. 542; Appun, Unter den Tropen, ii. 594.
Roraima range, 3500 ft., *McConnell & Quelch*, 604.
Mexico.

5. Alsophila villosa, Presl, ex Hook. Sp. Fil. i. p. 43; Appun, Unter den Tropen, ii. p. 594; Baker, in Trans. Linn. Soc. Ser. II. Bot. ii. (1887), p. 289. *Cyathea villosa*, H. B. & K. Nov. Gen. & Sp. i. p. 24, and vii. t. 670.
Roraima range, 3500 ft., *McConnell & Quelch*, 621.
British Guiana: Arapu River; also throughout Tropical South America.

6. Alsophila microphylla, Klotzsch, in Linnæa, xviii. (1844), p. 541.
Roraima range, 3500 ft., *McConnell & Quelch*, 606.
Venezuela and New Granada.

7. Dicksonia coniifolia, Hook. Sp. Fil. i. p. 70, t. 24. fig. A.
Summit of Roraima, 8600 ft., *McConnell & Quelch*, 564.
Jamaica, Venezuela, New Granada, and South Brazil.

8. Hymenophyllum crispum, H. B. & K. Nov. Gen. & Sp. i. p. 26.
Summit of Roraima, 8600 ft., *McConnell & Quelch*, 563.
Cuba, Jamaica, Mexico, Venezuela, New Granada, Ecuador, Peru, and Bolivia.

9. HYMENOPHYLLUM DEJECTUM, Baker, in Trans. Linn. Soc. Ser. II. Bot. ii. (1887), p. 289; Hook. Ic. Pl. t. 1610.

Roraima: upper slopes, *McConnell & Quelch*, 46; summit, *McConnell & Quelch*, 110, 113.

Endemic. Mr. im Thurn gathered it on the summit, as stated on p. 269 of Trans. Linn. Soc. Ser. II. Bot. ii. (1887).

10. HYMENOPHYLLUM POLYANTHOS, Sw. Syn. Fil. p. 149; R. Schomb. Reisen in Brit.-Guiana, iii. p. 1044. *H. clavatum*, Sw.; R. Schomb. Reisen in Brit.-Guiana, ii. p. 272, iii. p. 1044; Appun, Unter den Tropen, ii. p. 594. *H. Pœppigianum*, Presl; R. Schomb. Reisen in Brit.-Guiana, iii. p. 1044; Appun, Unter den Tropen, ii. p. 594.

Roraima range, 3500 ft., *McConnell & Quelch*, 611; upper slopes, *McConnell & Quelch*, 50 p.p., 73; summit, 8600 ft., *McConnell & Quelch*, 624.

British Guiana: Kwating Creek, Potaro River and Mazaruni River; also West Indies, Central America, the entire South American continent, Tropical and Subtropical Asia, New Zealand, Mascarene Islands, and Tropical Africa.

11. HYMENOPHYLLUM MICROCARPUM, Desv. in Mém. Soc. Linn. Paris, vi. (1827), p. 333.

Roraima: upper slopes, *McConnell & Quelch*, 44, 69.

Portorico, Guatemala, New Granada, Ecuador, Peru, Bolivia, and South Brazil.

12. HYMENOPHYLLUM SERICEUM, Sw. Syn. Fil. p. 146.

Summit of Roraima, 8600 ft., *McConnell & Quelch*, 628.

West Indies, Guatemala, French Guiana, New Granada, Ecuador, Peru, Bolivia, and South Brazil.

13. HYMENOPHYLLUM LINEARE, Sw. Fl. Ind. Occ. iii. p. 1749.

Roraima: upper slopes, *McConnell & Quelch*, 55 pro parte; summit, 8600 ft., *McConnell & Quelch*, 562.

Tropical America from the West Indies and Mexico southward to Peru and Brazil, Tropical and South Africa, and Mascarene Islands.

14. HYMENOPHYLLUM sp., *H. multifido*, Sw., affinis.

Mazaruni, between 250 and 3000 ft., *McConnell & Quelch*, 596, 598.

15. TRICHOMANES ELEGANS, Rudge, Pl. Guian. Rar. Ic. p. 24. *Hymenostachys elegans*, Presl; R. Schomb. Reisen in Brit.-Guiana, ii. p. 272; Appun, Unter den Tropen, ii. p. 594.

Roraima range, 3500 ft., *McConnell & Quelch*, 615; Mazaruni River, under 3000 ft., *McConnell & Quelch*, 594.

Central America, Trinidad, New Granada, Venezuela, and Northern Brazil.

In no. 594 the upper part of one of the fertile fronds is barren, and about six pairs of pinnæ have grown out in a similar manner to those of the barren fronds.

16. TRICHOMANES MACILENTUM, Van den Bosch, Hymenophyll. Nov. p. 12; Baker in Trans. Linn. Soc. Ser. II. Bot. ii. (1887), p. 289.

Mazaruni River, 250 ft., *McConnell & Quelch*, 578; between 250 and 3000 ft., *McConnell & Quelch*, 597.

British Guiana: upper slopes of Roraima; forests near the Kaieteur Savannah, Potaro River; Amutu, below the Kaieteur Fall, Potaro River; Macouria River; also in Trinidad and Brazil, especially the northern provinces.

This is regarded by Mr. Baker (Trans. Linn. Soc. *loc. cit.*) as a variety of *T. Bancroftii*, Hook. & Grev.

17. TRICHOMANES BANCROFTII, Hook. et Grev. Ic. Fil. t. 204; R. Schomb. Reisen in Brit.-Guiana, iii. p. 1043; Appun, Unter den Tropen, ii. p. 594.

Mazaruni River, between 250 and 3000 ft., *McConnell & Quelch*, 587.

British Guiana: Amutu and below the Kaieteur Fall on the Potaro River; also in the West Indies, Guatemala, French Guiana, Northern Brazil, and Peru.

18. TRICHOMANES BRACHYPUS, Kunze, in Linnæa, ix. (1834), p. 105; R. Schomb. Reisen in Brit.-Guiana, ii. p. 272, iii. p. 1043; Appun, Unter den Tropen, ii. p. 594. *T. Ankersii*, Parker; R. Schomb. *loc. cit.*; Appun, *loc. cit.*

Roraima range, 3500 ft., *McConnell & Quelch*, 609.

British Guiana: in the forest just below the Kaieteur Fall, Potaro River; Amutu, Potaro River; Tumbana-Capra; also in St. Vincent, Trinidad, Guatemala, French Guiana, Venezuela, New Granada, and Brazil.

19. TRICHOMANES PYXIDIFERUM, Linn., var. EMARGINATUM, Hook. et Baker, Syn. Fil. p. 81.

Mazaruni, between 250 and 3000 ft., *McConnell & Quelch*, 599.

British Guiana: upper slopes of Roraima; also in the Andes of Quito. The type occurs throughout the tropics of both hemispheres.

20. TRICHOMANES RADICANS, Sw. Fl. Ind. Occ. iii. p. 1736.

Roraima range, 3500 ft., *McConnell & Quelch*, 612.

Extending from the Southern United States, through Central America and the West Indies, to Southern Brazil and Bolivia; also in Western Europe, Atlantic Islands, West Africa, Mascarene Islands, Northern India, China, Japan, and Polynesia.

21. TRICHOMANES RORAIMENSE, Jenm. in Gard. Chron. Ser. III. xx. (1896), p. 716.

Summit of Roraima, 8600 ft., *McConnell & Quelch*, 108, 561.

22. TRICHOMANES CRISPUM, Linn. Sp. Pl. ed. 2, p. 1560; Baker, in Trans. Linn. Soc. Ser. II. Bot. ii. (1887), p. 289.

Roraima: upper slopes, *McConnell & Quelch*, 63; Roraima range, 3500 ft., *McConnell & Quelch*, 616.

British Guiana: Essequibo River; Berbice (coast); Corentyne River; forests near Kaieteur Savannah; Kaieteur Ravine; also West Indies, Central America, French Guiana, Venezuela, New Granada, Ecuador, Peru, Bolivia, Paraguay, throughout Brazil, and West Tropical Africa.

23. TRICHOMANES PINNATUM, Sw. Syn. Fil. p. 142. *Neurophyllum pinnatum*, Presl; R. Schomb. Reisen in Brit.-Guiana, iii. p. 1044.

Mazaruni, between 250 and 3000 ft., *McConnell & Quelch*, 585; Roraima range, 3500 ft., *McConnell & Quelch*, 614.

British Guiana: Potaro River, below the Kaieteur Fall; Kanaku Mountains; Karawanu Mountains; Corentyne River; Berbice; also in the West Indies, Guatemala, French Guiana, Venezuela, New Granada, Peru, Northern Brazil, and Chili.

24. TRICHOMANES PRIEURII, Kunze, Analect. Pterid. p. 48; R. Schomb. Reisen in Brit.-Guiana, ii. p. 272, iii. p. 1043. *T. rigidum*, Appun, Unter den Tropen. ii. p. 594.

Roraima range, 3500 ft., *McConnell & Quelch*, 613.

British Guiana: Kaieteur Ravine; Potaro River, below the Kaieteur Fall; also in the West Indies, French Guiana, Venezuela, New Granada, Ecuador, and Brazil from the Amazon region southward to Santa Catherina.

25. TRICHOMANES GEMMATUM, J. Sm. in Hook. Journ. Bot. iii. (1841), p. 417. *T. cellulosum*, Klotzsch in Linnæa, xviii. (1844), p. 531; R. Schomb. Reisen in Brit.-Guiana, ii. p. 272, iii. p. 1043.

Roraima range, 3500 ft., *McConnell & Quelch*, 608.

British Guiana: Kanaku Mountains; Amutu, Potaro River; Pacatout, below the Kaieteur Fall, Potaro River; also in Venezuela, Northern Brazil, Polynesia, the Philippines, Borneo and the Malay Peninsula.

26. LINDSAYA DUBIA, Spreng. Syst. Veg. iv. p. 79; R. Schomb. Reisen in Brit.-Guiana, iii. p. 1048.

Mazaruni, between 250 and 3000 ft., *McConnell & Quelch*, 593.

British Guiana: Roraima; Pacatout, below the Kaieteur Fall, Potaro River; Amutu, Potaro River; also in French Guiana.

27. LINDSAYA TRAPEZIFORMIS, Dryand. in Trans. Linn. Soc. iii. (1797), p. 42, var.

Roraima range, 3500 ft., *McConnell & Quelch*, 617.

Intermediate between var. *laxa*, Baker, and var. *arcuata*, Baker (in Mart. Fl. Bras. i. II. p. 355). The type is widely diffused in Tropical America, Asia, and Australia.

28. LINDSAYA STRICTA, Dryand. in Trans. Linn. Soc. iii. (1797), p. 42; im Thurn and Oliver, in Trans. Linn. Soc. Ser. II. Bot. ii. (1887), pp. 269, 290.

Roraima: upper slopes, *McConnell & Quelch*, 55, 62, 76; summit, 8600 ft., *McConnell & Quelch*, 497, 557.

British Guiana: Kaieteur Savannah; Head of Iteribisci Lake; also in the West Indies, Central America, French Guiana, Venezuela, New Granada, Peru, Bolivia, and throughout Brazil.

29. PTERIS AQUILINA, Linn., var. CAUDATA, Hook. Sp. Fil. ii. p. 196; im Thurn, in Trans. Linn. Soc. Ser. II. Bot. ii. (1887), p. 266.

Summit of Roraima, 8600 ft., *McConnell & Quelch*, 553.

Humirida Mountains; Florida, West Indies, Central America, Venezuela, Brazil, China, Malay Peninsula, and East Africa. The type is cosmopolitan.

30. PTERIS PALMATA, Willd. Sp. Pl. v. p. 357.

Kanuku Mountains, 1000 ft., *McConnell & Quelch*, 273.

British Guiana: Rupununi and Watu Ticaba; also in the West Indies, Central America, Venezuela, New Granada, Ecuador, Peru, Bolivia, Brazil, and New Guinea.

31. PTERIS INCISA, Thunb. Fl. Cap. ed. Schult. p. 733; Baker, in Trans. Linn. Soc. Ser. II. Bot. ii. (1887), p. 290.

Roraima: upper slopes, *McConnell & Quelch*, 75.

Also at the bottom of the cliff, Roraima. West Indies, Central America, Venezuela, New Granada, Galapagos Islands, Ecuador, South Brazil, Juan Fernandez, Chiloe, Polynesia, Himalaya, Formosa, Ceylon, Tasmania, Mascarene Islands, South Africa, and West Tropical Africa.

32. LOMARIA PROCERA, Spreng. Syst. Veg. iv. p. 65; Baker, in Trans. Linn. Soc. Ser. II. Bot. ii. (1887), p. 290.

Summit of Roraima, 8600 ft., *McConnell & Quelch*, 124, 566.

Throughout Tropical America from the West Indies and Mexico to Chili; also in Polynesia, Malaya, New Zealand, Tasmania, Southern Australia, Mascarene Islands, and South Africa.

33. LOMARIA BORYANA, Willd. Sp. Pl. v. p. 292; Baker, in Trans. Linn. Soc. Ser. II. ii. (1887), p. 290. *Lomaria Schomburgkii*, Klotzsch, in R. Schomb. Reisen in Brit.-Guiana, ii. p. 272, iii. p. 1050, and in Linnæa, xx. (1846), p. 346; Appun, Unter den Tropen, ii. p. 594.

Summit of Roraima, 8600 ft., *McConnell & Quelch*, 121.

West Indies, Venezuela, New Granada, Ecuador, Bolivia, South Brazil, Chili, Patagonia, Tristan d'Acunha, Tropical and South Africa, and the Mascarene Islands.

34. ASPLENIUM SERRATUM, Linn. Sp. Pl. ed. 1, p. 1078.

Roraima range, 3500 ft., *McConnell & Quelch*, 601.

British Guiana: Berbice; Kuyuni Creek; Oreala; also in Florida, West Indies, Central America, French Guiana, Venezuela, New Granada, Ecuador, Galapagos Islands, Peru, Bolivia, Paraguay, Brazil, and the Society Islands.

35. Asplenium lunulatum, Sw., var. erectum, Baker, in Mart. Fl. Bras. i. ii. p. 435 Oliver, in Trans. Linn. Soc. Ser. II. Bot. ii. (1887), p. 290. *A. harpeodes*, Kunze, in Linnæa, xviii. (1844), p. 329; R. Schomb. Reisen in Brit.-Guiana, iii. p. 1051; Appun, Unter den Tropen, ii. p. 595.

Upper slopes of Roraima, *McConnell & Quelch*, 45.

West Indies, Central America, Venezuela, New Granada, Ecuador, Peru, Bolivia, Argentine, Paraguay, Brazil, New Caledonia, India, Mascarene Islands, Tropical Africa, South Africa, and the Atlantic Islands.

36. Asplenium serra, Langsd. et Fisch. Pl. Voy. Russes, i. p. 16, t. 19; R. Schomb. Reisen in Brit.-Guiana, ii. p. 272, iii. p. 1051; Appun, Unter den Tropen, ii. p. 595.

Summit of Roraima, 8600 ft., *McConnell & Quelch*, 623.

British Guiana: Kwating Creek; also in Brazil, Venezuela, New Granada, Ecuador, Peru, New Caledonia, Tropical and South Africa, and the Mascarene Islands.

37. Asplenium auritum, Sw. Fl. Ind. Occ. iii. p. 1616; R. Schomb. Reisen in Brit.-Guiana, ii. p. 272, iii. p. 1051.

Roraima range, 3500 ft., *McConnell & Quelch*, 607.

West Indies, Central America, Venezuela, New Granada, Ecuador, Galapagos Islands, Peru, Bolivia, Brazil, South India, Madagascar, and East Tropical Africa.

38. Aspidium menisciodes, Willd. Sp. Pl. v. p. 218.

Roraima range, 3500 ft., *McConnell & Quelch*, 618.

British Guiana: Mazaruni Bush; Potaro River; Kabalebo River; Berbice; Essequibo River; also in Trinidad, French Guiana, Brazil, and Peru.

39. Nephrodium conterminum, Desv. in Mém. Soc. Linn. Paris, ii. (1827), p. 255; Baker, in Trans. Linn. Soc. Ser. II. Bot. ii. (1887), p. 290.

Summit of Roraima, 8600 ft., *McConnell & Quelch*, 627.

British Guiana: upper slopes of Roraima; also in Florida, West Indies, Central America, and South America southward to Chili and the Argentine.

This form has the ultimate segments more obtuse than the type.

40. Nephrodium denticulatum, Hook. Sp. Fil. iv. p. 147; Baker, in Trans. Linn. Soc. Ser. II. Bot. ii. (1887), p. 290.

Summit of Roraima, 8600 ft., *McConnell & Quelch*, 622.

Roraima: on the upper slopes and near the base of the cliff; also in the West Indies, Central America, Venezuela, New Granada, and Brazil.

41. Polypodium (§ Grammitis) Connellii, Baker, n. sp.; ad *P. gramineum*, Sw., accedit; differt frondibus glabris longioribus margine revolutis, soris haud contiguis regulariter biseriatis.

A densely cæspitose herb. Rhizome scarcely creeping; paleæ lanceolate, brown, membranous. Frond linear, simple, entire, 3–4 in. long, 1–1½ lin. wide, rigidly coriaceous, glabrous, gradually contracted into a very short, but distinct, stipe; veins immersed, concealed. Sori oblong, superficial, parallel with the midrib, often confluent.

Summit of Roraima, 8600 ft., *McConnell & Quelch*, 111, 118, 570.

42. Polypodium marginellum, Sw. Fl. Ind. Occ. iii. p. 1631; Baker, in Trans. Linn. Soc. Ser. II. Bot. ii. (1887), p. 291. *Mecosorus marginellus*, var. *major*, Klotzsch; R. Schomb. Reisen in Brit.-Guiana, iii. p. 1054.

Roraima: upper slope, *McConnell & Quelch*, 51; summit, 8600 ft., *McConnell & Quelch*, 117, 119, 568.

West Indies, Venezuela, Peru, Brazil, Samoa, and St. Helena.

Swartz (Fl. Ind. Occ. iii. p. 1631) says this species has "venis bifidis"; subsequent authors describe the veins as simple, which is the case in all the specimens at Kew.

43. Polypodium leptopodon, C. H. Wright, n. sp.; ad *P. marginellum*, Sw. accedit; differt fronde membranacea, marginibus ciliatis, venis unifurcatis, stipite elongato tenui piloso.

Rhizome shortly creeping, 2 lin. in diam., with brown lanceolate scales near the apex. Frond oblanceolate, obtuse, up to 2 in. long by 3 lin. broad, glabrous except for a few cilia on the margin when young, edged with a black line; veins once forked, conspicuous; sori few, near the apex of the frond, often confluent; stipe up to 2½ in. long, slender, pilose.

Summit of Roraima, 8600 ft., *McConnell & Quelch*, 569.

44. Polypodium furcatum, Mett. in Abhandl. Senck. naturf. Ges. ii. (1858), p. 34; Baker, in Trans. Linn. Soc. Ser. II. Bot. ii. (1887), p. 291.

Mazaruni, 250 ft., *McConnell & Quelch*, 576; between 250 and 3000 ft., *McConnell & Quelch*, 584.

British Guiana: upper slope of Roraima; below and above the Kaieteur, Potaro River; also in French Guiana, North Brazil, and the Island of Grenada.

45. Polypodium serrulatum, Mett. Fil. Hort. Bot. Lips. p. 30; Baker, in Trans. Linn. Soc. Ser. II. Bot. ii. (1887), p. 291. *Xiphopteris serrulata*, Kaulf.; R. Schomb. Reisen in Brit.-Guiana, ii. p. 272, iii. p. 1056.

Mazaruni, between 250 and 3000 ft., *McConnell & Quelch*, 592.

British Guiana: upper slopes of Roraima; also in the West Indies, Central America, Venezuela, New Granada, Ecuador, Peru, Bolivia, Brazil, Sandwich Islands, Mascarene Islands, and West Tropical Africa.

Var. strictissimum, Hook. Sp. Fil. iv. p. 175.

Summit of Roraima, 8600 ft., *McConnell & Quelch*, 555.

Ecuador.

46. POLYPODIUM TOVARENSE, Klotzsch, in Linnæa, xx. (1846), p. 374; Baker, in Trans. Linn. Soc. Ser. II. Bot. ii. (1887), p. 291.

Roraima: upper slopes, *McConnell & Quelch*, 67.

Venezuela, New Granada, and Ecuador.

47. POLYPODIUM MONILIFORME, Lag. in Sw. Syn. Fil. p. 33; Baker, in Trans. Linn. Soc. Ser. II. Bot. ii. (1887), p. 291.

Roraima: upper slopes, *McConnell & Quelch*, 47, 66; summit, 8600 ft., *McConnell & Quelch*, 558

West Indies, Central America, Andes of New Granada, Ecuador, and Bolivia.

48. POLYPODIUM HARTII, Jenm. in Journ. Bot. xxiv. (1886), p. 272.

Mazaruni, between 250 and 3000 ft., *McConnell & Quelch*, 591.

Jamaica, Dominica, and Island of Grenada.

49. POLYPODIUM TRICHOMANOIDES, Sw. Prodr. Veg. Ind. Occ. p. 131; R. Schomb. Reisen in Brit.-Guiana, iii. p. 1052; Appun, Unter den Tropen, ii. p. 595; Baker, in Trans. Linn. Soc. Ser. II. Bot. ii. (1887), p. 291.

Roraima: upper slopes, *McConnell & Quelch*, 49; Mazaruni, *McConnell & Quelch*, 575.

British Guiana: Kaieteur Ravine and Savannah; also in the West Indies, Central America, French Guiana, Brazil (Prov. Bahia), Ecuador, Peru, Juan Fernandez, Ascension Island, Northern India, and East Tropical Africa.

50. POLYPODIUM CULTRATUM, Willd. Sp. Pl. v. p. 187; R. Schomb. Reisen in Brit.-Guiana, ii. p. 272, iii. p. 1052; Baker, in Trans. Linn. Soc. Ser. II. Bot. ii. (1887), p. 292.

Roraima: upper slopes, *McConnell & Quelch*, 54, 56, 71.

British Guiana: Kaieteur Savannah; also in the West Indies, Central America, Venezuela, New Granada, Peru, Bolivia, Brazil, West Tropical Africa, and the Mascarene Islands.

51. POLYPODIUM XANTHOTRICHIUM, Klotzsch, in Linnæa, xx. (1846), p. 376; Baker, in Trans. Linn. Soc. Ser. II. Bot. ii. (1887), p. 292.

Roraima: upper slopes, *McConnell & Quelch*, 64, 68.

Endemic.

52. POLYPODIUM CAPILLARE, Desv. in Berl. Ges. naturf. Freunde, Mag. v. (1811), p. 316; Baker in Trans. Linn. Soc. Ser. II. Bot. ii. (1887), p. 292.

Roraima: upper slopes, *McConnell & Quelch*, 53, 58.

British Guiana: in woods near the Kaieteur Savannah; also in the West Indies, Venezuela, Ecuador, Peru, and Brazil.

53. POLYPODIUM KALBREYERI, Baker, in Trans. Linn. Soc. Ser. II. Bot. ii. (1887), p. 291.

Roraima: upper slopes, *McConnell & Quelch*, 65, 72.

New Granada.

54 Polypodium rigescens, Bory, in Willd. Sp. Pl. v. p. 183; Baker, in Trans. Linn. Soc. Ser. II. Bot. ii. (1887), p. 292.

Roraima: upper slopes, *McConnell & Quelch*, 18, 70; summit, 8600 ft., *McConnell & Quelch*, 559.

British Guiana: Kwating Creek; also in the West Indies, Venezuela, New Granada, Ecuador, Peru, Brazil, Solomon Islands, Mascarene Islands, and Tropical Africa.

55. Polypodium elasticum, Bory, in Willd. Sp. Pl. v. p. 183.

Makarapan Mt. on the north of Kwaimatta, 2000 ft., *McConnell & Quelch*, 278.

British Guiana: Kwating Creek; Berbice; also in Florida, the West Indies, Central America, New Granada, Ecuador, Peru, Bolivia, Paraguay, and Brazil.

56. Polypodium meridense, Klotzsch. in Linnæa, xx. (1846), p. 380.

Summit of Roraima, 8600 ft., *McConnell & Quelch*, 498, 499, 560.

Venezuela, New Granada, South Brazil.

7. Polypodium incanum, Sw. Syn. Fil. p. 35.

Kanaku Mts., 500 ft., *McConnell & Quelch*, 271.

British Guiana: Savannah Bush; Rupununi; Corentyne River; also in the Southern United States, West Indies, Central America, French Guiana, Venezuela, New Granada, Peru, Brazil, Paraguay, Uruguay, Chili, South Africa, and the Zambesi.

58. Polypodium crassifolium, Linn. Sp. Pl. ed. 1, p. 1083; R. Schomb. Reisen in Brit.-Guiana, iii. p. 1053; Appun, Unter den Tropen, ii. p. 595.

Roraima range, 3500 ft., *McConnell & Quelch*, 603.

West Indies, Central America, French Guiana, Surinam, Venezuela, New Granada, Ecuador, Galapagos Islands, Peru, Bolivia, Brazil.

59. Gymnogramme cyclophylla, Baker, in Trans. Linn. Soc. Ser. II. Bot. ii. (1887), p. 293, t. 53.

Summit of Roraima, 8600 ft., *McConnell & Quelch*, 116, 120, 567.

Endemic.

60. Gymnogramme elaphoglossoides, Baker, in Trans. Linn. Soc. Ser. II. Bot. ii. (1887), p. 293, t. 54.

Summit of Roraima, 8600 ft., *McConnell & Quelch*, 112, 554.

Endemic.

61. Gymnogramme pumila, A. Spreng. Tent. Suppl. ad Syst. Veg. p. 31; R. Schomb. Reisen in Brit.-Guiana, iii. p. 1054.

Mazaruni, 250 ft., *McConnell & Quelch*, 491.

British Guiana: Rupununi River; also in the West Indies, Central America, New Granada, and Brazil.

62. Gymnogramme flexuosa, Desv. in Mém. Soc. Linn. Paris, ii. (1827), p. 215; Baker, in Trans. Linn. Soc. Ser. II. Bot. ii. (1887), p. 293.

Roraima: upper slopes, *McConnell & Quelch*, 59; summit, 8600 ft., *McConnell & Quelch*, 629.

Central America, Venezuela, New Granada, Ecuador, Peru, Bolivia, and Brazil.

63. Acrostichum simplex, Sw., var. martinicense, Hook. et Baker, Syn. Fil. ed. 1, p. 400.

Mazaruni, between 250 and 3000 ft., *McConnell & Quelch*, 581.

British Guiana: Essequibo River and on the coast; also in the West Indies, New Granada, Ecuador, Peru, and Brazil.

64. Acrostichum conforme, Sw. Syn. Fil. pp. 10, 192, t. 1. fig. 1.

Mazaruni, 250 ft., *McConnell & Quelch*, 577.

British Guiana: Essequibo River and on the coast; also in the West Indies, Central America, Venezuela, New Granada, Ecuador, Peru, Chili, Brazil, Polynesia, Queensland, India, Mascarene Islands, Tropical and South Africa.

The form of this polymorphic species represented in this collection has been named *Acrostichum alatum*, Fée (Mém. Fam. Fougèr. ii. p. 35, t. 5. fig. 2).

65. Acrostichum latifolium, Sw. Fl. Ind. Occ. iii. p. 1589; Baker, in Trans. Linn. Soc. Ser. II. Bot. ii. (1887), p. 294.

Summit of Roraima, 8600 ft., *McConnell & Quelch*, 571.

British Guiana: upper slopes of Roraima; Asabaru Creek; Sheenabowa and Kaieteur Ravine, Potaro River; Demerara River and on the coast; also throughout the West Indies and Tropical America, and widely diffused in Polynesia, Java, Mascarene Islands, Tropical and South Africa.

66. Acrostichum squamosum, Sw. in Schrad. Journ. Bot. iv. (1800), p. 11; Baker, in Trans. Linn. Soc. Ser. II. Bot. ii. (1887), p. 295.

Roraima: upper slopes, *McConnell & Quelch*, 57.

British Guiana: Kaieteur Savannah and Essequibo River; also in the West Indies, Central America, Venezuela, Ecuador, Brazil, Sandwich Islands, Ceylon, South India, Mascarene Islands, Tropical Africa, and the Atlantic Islands.

67. Acrostichum decoratum, Kunze, in Linnæa, ix. (1834), p. 25; Baker, in Trans. Linn. Soc. Ser. II. Bot. ii. (1887), p. 294.

Roraima range, 3500 ft., *McConnell & Quelch*, 602.

West Indies, Peru, and South Brazil.

68. Acrostichum peltatum, Sw. Fl. Ind. Occ. iii. p. 1593; Appun, Unter den Tropen, ii. p. 595; Baker, in Trans. Linn. Soc. Ser. II. Bot. ii. (1887), p. 295.

Roraima: upper slopes, *McConnell & Quelch*, 61; Mazaruni, between 250 and 3000 ft., *McConnell & Quelch*, 582.

West Indies, Central America, Venezuela, New Granada, Ecuador, and Brazil.

69. ACROSTICHUM OLIGARCHICUM, Baker, in Hook. et Baker, Syn. Fil. ed. 1, p. 418.
Roraima range, 3500 ft., *McConnell & Quelch*, 600.
North Peru.

70. SCHIZÆA FLUMINENSIS, Miers, in Mart. Fl. Bras. i. pars II. p. 184, t. 15. fig. 2.
Mazaruni, between 250 and 3000 ft., *McConnell & Quelch*, 580.

British Guiana: Kukenaam, and woods at the side of the Kaieteur Savannah; also in Venezuela and Brazil.

71. SCHIZÆA ELEGANS, Sw. Syn. Fil. p. 151; Baker, in Trans. Linn. Soc. Ser. II. Bot. ii. (1887), p. 295.
Mazaruni, between 250 and 3000 ft., *McConnell & Quelch*, 589.

British Guiana: Essequibo River; Epiro Creek, Corentyne River; Demerara River, and on the coast; also in the West Indies, Central America, Surinam, Venezuela, New Granada, and Brazil.

72. SCHIZÆA PENNULA, Sw. Syn. Fil. pp. 150, 379. *Actinostachys pennula*, Hook.; R. Schomb. Reisen in Brit.-Guiana, iii. p. 1045.
Mazaruni, between 250 and 3000 ft., *McConnell & Quelch*, 588.

British Guiana: Roraima; Kukuya Creek; Kaieteur Savannah; Serra Mey and Demerara River; also in the West Indies, Surinam, Brazil, and New Caledonia.

73. ANEMIA TOMENTOSA, Sw. Syn. Fil. p. 157; Baker, in Trans. Linn. Soc. Ser. II. Bot. ii. (1887), p. 295.
Kanuku Mountains, 1000 ft., *McConnell & Quelch*, 272, 274.

Var. FULVA, Hook. et Baker, Syn. Fil. ed. 1, p. 433.
Ireng Valley, *McConnell & Quelch*, 201.

British Guiana: Roraima and Rupununi; also in the West Indies, Central America, Venezuela, New Granada, Peru, Paraguay, Brazil, and Uruguay.

74. LYCOPODIUM ALOPECUROIDES, Linn. Sp. Pl. ed. 2, p. 1565; Baker, in Trans. Linn. Soc. Ser. II. Bot. ii. (1887), p. 295; Jenman, in Timehri, v. (1886), p. 44.
Roraima: upper slopes, *McConnell & Quelch*, 60.
Southern United States, Venezuela, New Granada, Peru, Brazil, Bolivia, and Uruguay.

75. LYCOPODIUM CERNUUM, Linn. Sp. Pl. ed. 2, p. 1566: Jenman, in Timehri, v. (1886) p. 45.
Ireng Valley, *McConnell & Quelch*, 206.

British Guiana: Corentyne, Pomeroon and Macouria Rivers and at Berbice; also throughout the tropics and extending a short distance on either side.

76. LYCOPODIUM CONTIGUUM, Klotzsch, in Linnæa, xviii. (1844), p. 519.
Summit of Roraima, 8600 ft., *McConnell & Quelch*, 572.
Higher parts of the Andes in Venezuela, New Granada, Ecuador, and Bolivia.

77. **Lycopodium clavatum**, Linn. Sp. Pl. ed. 2, p. 1564; Jenman, in Timehri, v. (1886), p. 44.

Roraima range, 3500 ft., *McConnell & Quelch*, 707.

Arctic and alpine zones of both hemispheres, also on the mountains throughout the tropics.

78. **Lycopodium carolinianum**, Linn. Sp. Pl. ed. 2, p. 1567; Jenman, in Timehri, v. (1886), p. 43.

Roraima: upper slopes, *McConnell & Quelch*, 52.

British Guiana: Kaieteur Savannah; Corentyne River; Kako Creek; Demerara; also in Florida, Guadeloupe, Brazil, Paraguay, Hongkong, Ceylon, Mascarene Islands, and South Africa.

79. **Selaginella vernicosa**, Baker, in Trans. Linn. Soc. Ser. II. Bot. ii. (1887), p. 295, t. 56. f. A.

Summit of Roraima, 8600 ft., *McConnell & Quelch*, 574, ex parte.

Also found by im Thurn at the base of the cliff.

Var. **oligoclada**, Baker, *l. c.* fig. B.

Summit of Roraima, 8600 ft., *McConnell & Quelch*, 574, ex parte.

80. **Selaginella flabellata**, Spring, Monogr. Lycopod. p. 174.

Essequibo River, *McConnell & Quelch*, 115.

British Guiana: foot of the Kaieteur. Tropics and subtropics of America, Asia, and Polynesia.

81. **Selaginella anceps**, A. Br. in Ann. Sc. Nat. Sér. V. iii. (1865), p. 278.

Roraima range, 3500 ft., *McConnell & Quelch*, 706.

British Guiana: Potaro River; also in Guatemala, Venezuela, New Granada, Ecuador, and Peru.

III. BRYOPHYTA.

MUSCI by V. F. Brotherus, Ph.D.

DICRANACEÆ.

Dicranum longisetum, Hook. Musc. Exot. t. 139.

Mount Roraima, *McConnell & Quelch*, 343.

Found in the mountains of Venezuela, New Granada, and Quito.

Var. **laxifolium**, Broth. n. var. Folia laxius disposita, apice argutius serrulata.

Mount Roraima, Ledge, 7500–8000 ft., *McConnell & Quelch*, 344.

DICRANODONTIUM PULCHRO-ALARE, Broth., n. sp. *Dioicum*, cæspitosum, cæspitibus densiusculis lutescentibus nitidis; *caulis* 8 cm., sterilis usque ad 12 cm. altus, arcuato-flexuosus, fusco-tomentosus, densiuscule foliosus, sæpe innovationibus elongatis gracilibus. *Folia* falcata, canaliculato-concava, e basi lanceolata longe subulata, usque ad 1 cm. longa, superne dense et argute serrulata, nervo basi folii latitudinis tertiam partem vel paulum ultra occupante et superne dorso serrulato ibidemque folium totum occupante; cellulæ superiores angustæ; basilares ad nervum laxæ, rectangulares, hyalinæ; exteriores angustissimæ, limbum multiseriatum efformantes; alares in ventrem magnum fugacem dispositæ, laxæ, teneræ, fuscæ. *Bracteæ perichætii* internæ e basi vaginante subito in subulam integram attenuatæ, cellulis omnibus elongatis angustis teneris. *Seta* 2·5 cm. alta, tenuis, serpentino-flexuosula, lutea, apice cygnea, rubra. *Theca* sicca erecta, plicata, humida ob setam apice cygneam horizontalis, lævis, oblonga, c. 2·5 mm. alta, leptodermis, fuscidula. *Peristomium* simplex; *exostomii* dentes 16, aurantiaci, c. 0·37 mm. longi et c. 0·075 mm. lati, usque ad basin in cruribus duobus filiformibus inæqualibus articulatis dense papillosis divisi; *spori* 0·017 mm., fusci, papillosi. *Cætera* ignota.

Mount Roraima, Ledge, 7500–8000 ft., *McConnell & Quelch*, 345, 346.

Endemic.

CAMPYLOPUS CHIONOPHILUS, Mitt. in Journ. Linn. Soc., Bot. xii. (1869), p. 81. *Dicranum chionophilum*, C. Muell. Syn. i. 398.

Mount Roraima, Ledge, 7500–8000 ft., *McConnell & Quelch*, 342.

Found in the mountains of New Granada.

CAMPYLOPUS RORAIMÆ, Broth., n. sp. *Dioicus*, cæspitosus, cæspitibus densis nigrescentibus superne lutescentibus etiamque nitidiusculis; *caulis* ad 3 cm. usque altus, tomentosus, dense et per totam longitudinem æqualiter foliosus, ramosus. *Folia* homomallula, erecto-patentia, canaliculato-concava, e basi oblongo-lanceolata, breviter subulata, c. 5 mm. longa et c. 0·75 mm. lata, marginibus summo apice serratis, nervo basi dimidiam partem folii latitudinis occupante, lamina usque ad apicem folii distincta; cellulæ basilares subrectangulares, inter se porosæ, marginem versus angustiores, dein rhomboideæ; superiores rhombeæ, incrassatæ; alares numerosæ, subquadratæ, rubræ, basin totam occupantes. *Cætera* ignota.

Mount Roraima, Ledge, 7500–8000 ft., *McConnell & Quelch*, 347.

Endemic.

Species *C. concolori*, Brid. affinis, sed foliis multo brevioribus primo visu dignoscenda.

CAMPYLOPUS ATRATUS, Broth., n. sp. *Dioicus*, robustus, ater, apice lutescens, nitidiusculus. *Caulis* 10 cm. altus, erectus, haud tomentosus, dense et per totam longitudinem æqualiter foliosus, parce ramosus; *folia* sicca suberecta, humida recurvulo-patentia, canaliculato-concava, superne tubulosa, e basi lanceolata longe et anguste subulata, pilo stricto tenui hyalino longiusculo serrato terminata,

c. 10 mm. longa et c. 1·1 mm. lata, marginibus integris superne conniventibus, nervo basi tertiam partem folii latitudinis occupante, lamina usque ad apicem folii distincta; cellulæ elongatæ, angustæ, marginem versus incrassatæ, lumine angustissimo, limbum inferne latiusculum hyalinum superne tenuiorem, ultra medium evanidum efformantes, alares numerosæ, subquadratæ, rubræ, in ventrem distinctum dispositæ. *Cætera* ignota.

Summit of Mount Roraima, 8600 ft., *McConnell & Quelch*, 527.

Endemic.

Species cum *Campylopode griseo*, Hornsch., comparanda, sed statura multo robustiore, foliis strictipilis, integris, tubulosis, limbatis facillime dignoscenda.

LEUCOBRYACEÆ.

Leucobryum megalophyllum, Mitt. in Journ. Linn. Soc., Bot. xii. (1869), p. 112. *Dicranum megalophyllum*, Raddi, Critt. Bras. p. 3. *Leucobryum giganteum*, C. Muell. Syn. i. p. 79, ii. p. 536. *Leucobryum robustum*, Sull. in Proc. Amer. Acad. (1861), p. 279.

Mount Roraima, Ledge, 7500–8000 ft., *McConnell & Quelch*, 351 (forma).

Found in Cuba, Jamaica, Trinidad, Barbados, New Granada, Venezuela, and Brazil.

Leucobryum crispum, C. Muell. Syn. i. p. 78.

Roraima range at 3500 ft., *McConnell & Quelch*, 546.

Found in the West-Indian Islands, Venezuela, New Granada, and Brazil.

Leucobryum lævifolium, Broth. *Dioicum*, robustiusculum, cæspitosum, cæspitibus mollibus dilabentibus lutescenti-albidis ætate fuscescentibus nitidis; *caulis* usque ad 6 cm. altus, erectus, dense foliosus, plerumque fasciculatim ramosus, ramis fastigiatis. *Folia* sicca et humida suberecta, stricta vel rarius homomallula, canaliculato-concava, e basi oblongo-lanceolata sensim acuminata, acuta, 5–6 mm. longa et c. 0·66 mm. lata, dorso sicca et humida lævissima, marginibus superne involutaceis integerrimis, limbata, limbo hyalino, inferne e seriebus cellularum 7–8 formato, superne angustiore, apice obsoleto, lamina e stratis cellularum æqualium duobus composita. *Cætera* ignota.

Summit of Mount Roraima, 8600 ft., *McConnell & Quelch*, 505, 536.

Species *L. Martiano*, Hampe, affinis, sed statura robustiore, nitore foliisque strictis, raro indistincte homomallulis oculo nudo jam dignoscenda.

Octoblepharum Mittenii, Jaeg. Adumbr. i. p. 169. *Octoblepharum longifolium*, Mitt. in Journ. Linn. Soc., Bot. xii. (1869), p. 110.

Summit of Mount Roraima, 8600 ft., *McConnell & Quelch*, 517.

Found in Brazil.

TORTULACEÆ.

Leptodontium cirrhifolium, Mitt. in Journ. Linn. Soc., Bot. xii. (1869), p. 52.

Summit of Mount Roraima, 8600 ft., *McConnell & Quelch*, 511.

Found in the mountains of Quito.

GRIMMIACEÆ.

MACROMITRIUM MUCRONIFOLIUM, Schwaegr. Suppl. ii. II. I. p. 167, t. 172.

Roraima range, 3500 ft., *McConnell & Quelch*, 544.

Found in Florida, in the West-Indian Islands, Guiana, Surinam, and Brazil.

ZYGODON SUBDENTICULATUS, Hampe, Ann. Sc. Nat. Sér. V. iv. (1863–67), p. 326.

Summit of Mount Roraima, *McConnell & Quelch*, 540.

Found in New Granada.

FUNARIACEÆ.

FUNARIA CALVESCENS, Schwaegr. Suppl. i. II. p. 77, t. 65.

Mount Roraima, Ledge, 7500–8000 ft., *McConnell & Quelch*, 338.

Found in South Europe and in the tropical and subtropical regions of Asia, Africa, America, and Australia.

BARTRAMIACEÆ.

BREUTELIA SCOPARIA, Besch. in Ann. Sc. Nat. Sér. VI. iii. (1876), p. 209. *Bartramia scoparia*, Schwaegr. Suppl. iii. I. I. t. 211.

Summit of Mount Roraima, 8600 ft., *McConnell & Quelch*, 514.

Found in the West-Indian Islands.

MNIACEÆ.

RHIZOGONIUM LINDIGII, Mitt. in Journ. Linn. Soc., Bot. xii. (1869), p. 328. *Mnium Lindigii*, Hampe, in Ann. Sc. Nat. Sér. V. iv. (1863–67), p. 345.

Summit of Mount Roraima, 8600 ft., *McConnell & Quelch*, 502, 537.

Found in Costa Rica and in the mountains of New Granada.

MNIUM ROSTRATUM, Schrad. in Linn. Syst. Nat. 13 ed. Gmel. ii. pars II. p. 1330.

Roraima, Ledge, 7500–8000 ft., *McConnell & Quelch*, 339.

Found in all parts of the world.

NECKERACEÆ.

RHACOCARPUS HUMBOLDTII, Lindb. in Öfvers. Svensk. Vet.-Ak. Förh. (1862). *Harrisonia Humboldtii*, Spreng. Syst. Veg. iv. I. p. 145.

Mount Roraima, Ledge, 7500–8000 ft., *McConnell & Quelch*, 336, and summit of Mount Roraima, 519, 534 (var. *fusco-viridis*).

Found in the mountains of New Granada.

PILOTRICHUM BIPINNATUM, Brid. Bryol. Univ. ii. p. 283.

Roraima range, 3500 ft., *McConnell & Quelch*, 548.

Found in the West-Indian Islands, in Guiana, Brazil, and in the mountains of Quito and Peru.

HOOKERIACEÆ.

Hookeria (§ **Hylotapis**) **pilotrichelloides**, Broth., n. sp. *Robustiuscula*, mollis, fusco-aurea, nitida; *caulis* usque ad 15 cm. longus, flexuosus, complanatulus, dense foliosus, per totam longitudinem pinnatim ramosus, ramis vix ultra 1 cm. longis patentibus strictis vel arcuatulis complanatulis dense foliosis obtusis. *Folia* sicca imbricata, humida suberecta, cymbiformi-concava, oblonga vel ovato-oblonga, in apiculum acutum, recurvulum subito contracta, marginibus inferne revolutis, integerrimis vel apice minutissime crenulatis, nervis binis elongatis vix divergentibus longe infra apicem evanidis dorso lævibus; cellulæ angustissime lineares, seriatim papillosæ; basilares læves; infimæ laxæ, breves, fusco-aureæ. *Cætera* ignota.

Mount Roraima, Ledge, 7500–8000 ft., *McConnell & Quelch*, 337.

Endemic.

Species pulcherrima, mollitie necnon caule longissimo *Pilotrichellis* nonnullis similis, cum nulla alia commutanda.

Hookeria (§ **Omaliadelphus**) **Roraimæ**, Broth., n. sp. *Dioica*, robusta, lutescenti-viridis, ætate fusco-aurea, nitida; *caulis* usque ad 20 cm. longus, complanatulus, dense foliosus, dense pinnatim ramosus, ramis patulis, 1–1·5 cm. longis, strictis, complanatulis, dense foliosis, obtusis; *folia* sicca laxe imbricata, valde undulata, humida erecto-patentia, concaviuscula; *lateralia* oblongo-lanceolata, breviter acuminata, acutiuscula, marginibus inferne revolutis dein erectis minute serrulatis, nervis binis tenuibus parce divergentibus infra apicem evanidis dorso superne denticulatis: cellulæ elongatæ, angustissime lineares; basilares infimæ laxæ, fusco-aureæ, omnes lævissimæ; *bracteæ perichætii* internæ e basi ovata sensim subulatæ, minute denticulatæ, enerves; *seta* 1·5 cm. vel paulum ultra alta, sat tenuis, rubra, lævissima; *theca* horizontalis, e collo brevi ovalis, sicca deoperculata sub ore haud constricta, fusca; *peristomium* duplex; *exostomii* dentes e basi lanceolata longissime subulati, c. 0·95 mm. longi et c. 0·14 mm. lati, latiuscule exarati, dense et alte lamellati, aurantiaci; *endostomium* sordide luteum, minute papillosum; *processus* carinati, vix perforati; *operculum* longe et anguste subulatum; *calyptra* ad medium thecæ producta, basi multifida, apice fusca, glabra.

Roraima range, 3500 ft., *McConnell & Quelch*, 490, 550.

Endemic.

Species pulcherrima, statura robusta ab omnibus speciebus sectionis oculo nudo jam dignoscenda.

STEREODONTACEÆ.

Ectropothecium amabile, Mitt. in Journ. Linn. Soc., Bot. xii. (1869), p. 514.

Mount Roraima, Ledge, 7800–8000 ft., *McConnell & Quelch*, 341, and summit of Mount Roraima, 8600 ft., 516, 542.

Found in the mountains of New Granada.

CTENIDIUM MALACODES, Mitt. in Journ. Linn. Soc. Bot. xii. (1869), p. 509.
Mount Roraima, Ledge, 7500–8000 ft., *McConnell & Quelch*, 340.
Found in the mountains of New Granada and Quito.

LESKEACEÆ.

THUIDIUM ANTILLARUM, Besch. in Ann. Sc. Nat. Sér. VI. iii. (1876), p. 244.
Roraima range, 3500 ft., *McConnell & Quelch*, 549.
Found in Costa Rica and the West-Indian Islands.

THUIDIUM PSEUDO-PROTENSUM, Mitt. in Journ. Linn. Soc., Bot. xii. (1869), p. 578.
Hypnum pseudo-protensum, C. Muell. in Bot. Zeit. vi. (1848), col. 779.
Mount Roraima, Ledge, 7500–8000 ft., *McConnell & Quelch*, 348.
Found in Venezuela.

SPHAGNACEÆ.

SPHAGNUM SANGUINALE, Warnst. in Bot. Centralbl. lxxvi. (1898), p. 385.
Mount Roraima, Ledge, 7500–8000 ft., *McConnell & Quelch*, 350, 541 in part.
Endemic.

SPHAGNUM MEDIUM, Limpr. in Bot. Centralbl. vii. (1881), p. 313.
Mount Roraima, Ledge, 7500–8500 ft., *McConnell & Quelch*, 349, 541 in part.
Found in Europe and in America from Labrador to Patagonia.

HEPATICÆ. By F. STEPHANI.

The collection of Liverworts made by Messrs. McConnell and Quelch is a small one, but is of particular interest from a geographical point of view. Many plants were found which hitherto had been only observed in the Andes of South America; their unexpected appearance on the top of Mount Roraima is quite startling: the curious *Frullania mirabilis*, Jack et Steph., is of particular interest, as well as the very rare and beautiful *Pleurozia paradoxa*, Jack, both of which up to this time had not been elsewhere collected.

It is possible that some of these plants may have intermediate stations of which we are at present ignorant; but a similar surprising collection was made by Mr. Ule (of the Botanic Garden of Rio Janeiro) in the Serra do Mar and the Serra Itatiaia, where Andine forms were collected, though stations forming connecting-links are altogether missing.

There are also several new species, amongst which *Metzgeria inflata* is one of the most curious in the genus, being quite hairless and almost without any rootlets, lying like a small inflated cylindric pouch amongst other mosses.

As cryptogamic plants, and in particular Liverworts, with few exceptions, have very small spores and live in sheltered and moist places from where the wind cannot easily carry away the spores, they are a better indication than phænogamic plants as to the Flora we must regard as the remnant of another, which, like that of South America, once covered a wide area, and is now separated by intermediate barren plains or treeless Llanos and Pampas of enormous extension where no Liverworts can live.

That the spores are not able to propagate a Liverwort beyond, perhaps, a small area, no better example can show than the very interesting flora of Killarney, where—doubtless for many centuries—a few species of Hepaticæ of tropical origin have been preserved without being able to reach the Continent.

The present condition of the literature of Liverworts seldom allows one to make geographical speculations; but when my "Species Hepaticarum" is finished, and the number and relation of known liverworts, as also their distribution, settled, we may be able to draw conclusions which, I think, will be of value to all who study the geographical distribution of plants.

The following Liverworts have been collected, viz.:—

A. ANACROGYNÆ.

1. **DUMORTIERA HIRSUTA**, Nees, Hep. Eur. iv. p. 163. *Marchantia hirsuta*, Sw. Prodr. Fl. Ind. Occ. p. 145.
Roraima, Ledge, 7500–8000 ft., *McConnell & Quelch*, 334/6.
Common in Tropical and Subtropical America, England, Italy, Africa.

2. **ANEURA SCHWANECKEI**, Steph. in Hedwigia xxvii. (1888), p. 278.
Summit of Roraima, *McConnell & Quelch*, 512.
Found also in the West-Indian Islands.

3. **ANEURA ALGOIDES**, Steph. in Bull. Herb. Boiss. vii. (1899), p. 682. *Metzgeria algoides*, Taylor, in Hook. Lond. Journ. Bot. v. (1846), p. 410.
Summit of Roraima, *McConnell & Quelch*, 529.
An Andine plant, collected by Jameson near Quito.

4. **ANEURA RORAIMENSIS**, Steph., n. sp. *Dioica*, minor, pallide olivacea, aliis hepaticis consociata. *Frons* ad 5 mm. longa, exalata, irregulariter bipinnata, sæpe subfasciculata. *Truncus* primarius angustus, biconvexus, ramis trunco latioribus minus convexis. *Cuticula* ubique lamellata, lamellis denticulatis margine bene prominulis. *Cellulæ* frondis internæ corticalibus multo majores, fronde in adspectu itaque optime reticulata. *Rami feminei* in trunco solitarii, breves, margine latissime alati, alis profunde inciso-lobatis, lobis lanceolatis vel ligulatis obtusis, squama basali similiter lobata ramulum ♀ a tergo tegente. *Reliqua* desunt.

A very good and most distinct species, easily to be recognized by the rough cuticula of the cortical cells.

In the monograph of the genus *Aneura* ('Species Hepticarum,' p. 736) it is to be placed after No. 81, *Aneura scabra*, Steph.

Summit of Roraima, *McConnell & Quelch*, 350. Mixed with *Micropterygium pterygophyllum*, Spruce.

5. Aneura Breutelii, Steph. in Bull. Herb. Boiss. vii. (1899), p. 759.
Summit of Roraima, *McConnell & Quelch*, 533.
Collected before by Breutel in the West-Indian Island of St.Kitts.

6. Aneura fucoides, Steph. in Bull. Herb. Boiss. vii. (1899), p. 680. *Jungermannia fucoides*, Sw. Prodr. fl. Ind. occ. p. 45.
Roraima, Ledge, 7500–8000 ft., *McConnell & Quelch*, 334/6 in part.
Common in Tropical America.

7. Metzgeria inflata, Steph., n. sp. *Dioica*, spectabilis, brevis, flaccida, pallide lurida, optime nitida, muscis consociata. *Frons* furcata, ad 3 cm. longa, omnino nuda, basi tantum paucis radicellis affixa. *Costa* tenuis, cellulis corticalibus utroque latere biseriatis tecta et in sectione transversa late ovalis; cellulæ antice et postice magnæ, æquales, internæ multo minores triseriatæ. *Alæ* apice cucullatæ, ubique maxime irregulariterque revolutæ, in sectione transversa valde asymmetricæ, uno latere quadruplo latiores, re vera itaque sinuatim lobatæ, lobis bulloso inflatis ob flexuram tamen haud discretis. *Cellulæ* alarum 36–54 μ, parietibus validis, trigonis parvis. *Rami feminei* parvi, fere conduplicati, margine breviter setosi.
Summit of Roraima, *McConnell & Quelch*, 524.

This plant is well adapted to retain the water which it takes up from the mosses on which it is growing in rather exposed places on the very summit of the mountain; it may be compared to the Tasmanian species *M. saccata*, Mitt., which prefers to grow on the uppermost twigs of trees, where it has a similar exposed situation and shows a similar adaptation to retain the water within the inflated lobes of the thallus.

8. Metzgeria hamata, Lindb. Monogr. Metzg. p. 25.
Roraima, Ledge, 7500–8000 ft., *McConnell & Quelch*, 334/4 and 5.
Common in all parts of the globe.

9. Monoclea Gottschei, Lindb. in Rev. Bryol. xiii. (1886), p. 102, in adnot.
Roraima, at 3500 ft., *McConnell & Quelch*, 551.
West-Indian Islands and the northern part of South America, Chile, Peru.

This plant has been distributed by Gottsche and others under the name of *Monoclea Forsteri*, a very different plant and altogether antarctic (New Zealand and Patagonia).

10. Pallavicinius Wallisii, J. B. Jack & Steph. in Hedwigia, xxxi. (1892), p. 23.
Summit of Roraima, *McConnell & Quelch*, 501.

Collected before by Wallis in the mountains of New Granada near Antioquia, 8000 ft.

B. ACROGYNÆ.

11. JAMESONIELLA COLORATA, Spruce, in Journ. Bot. xvi. (1876), p. 30. *Jungermannia colorata*, Lehm. in Linnæa, iv. (1829), p. 366.

Summit of Roraima, *McConnell & Quelch*, 539 in part.

America, Australia, South Africa. Very common.

12. SYZYGIELLA QUELCHII, Steph., n. sp. *Sterilis* magna, fusco-purpurascens, tenera et flaccida, aliis hepaticis sparsim consociata. *Caulis* ad 8 cm. longus simplex (semper?). *Folia* opposita, conferta, assurgentia, si alam decurrentem anticam excipis oblique falcato-ovata, apice duplo angustiora quam basi, oblique truncata vel lenissime emarginata, omnino integerrima, angulis solum dentiformibus; *margine postico* valde arcuato, basi folii oppositi brevissime coalito ibidemque *hamatim auriculato*, *margine antico* substricto breviter recurvo, longe decurrente, folia tamen antice haud attenuata sed oblique truncata et abrupte desinentia, folio opposito minime coalita. *Cellulæ* foliorum nodulose incrassatæ, nodulis maximis nusquam confluentibus, multo majores quam in *S. manca*, Steph.

Roraima, Ledge, 7500–8000 ft., *McConnell & Quelch*, 334/14 in part.

A most beautiful and very curious plant; the two opposite leaves are quite erect and touch each other, the stem being perfectly hidden when seen from above. At the postical base these two leaves are united for a very short space; just above this point they are rounded off and much projecting, and have a large incurved acuminate lobule.

13. SYZYGIELLA PERFOLIATA, Spruce, in Trans. Edinb. Bot. Soc. xv. (1885), p. 500, in adnot. *Jungermannia perfoliata*, Sw. Prodr. Veg. Ind. Occ. p. 143.

Summit of Roraima, *McConnell & Quelch*, 524 in part.

Found in Venezuela and the West Indies.

14. PLAGIOCHILA AËREA, Taylor, in Hook. Lond. Journ. Bot. v. (1846), p. 263.

Roraima, Ledge, 7500–8000 ft., *McConnell & Quelch*, 334.

Found before in Venezuela and Mexico.

15. PLAGIOCHILA GAVANA, Steph., n. sp. *Dioica*, spectabilis, pallide glauco-virens, ætate flavo-virens, effuse cæspitans. *Caulis* ad 10 cm. longus, longe remoteque pauci-ramosus, ramis late divergentibus, apice sæpe fasciculatis ubique æqualiter foliatis. *Folia* magna, tenera, remotiuscula, basi tantum imbricata, subrecte patula, breviter inserta, *i. e.* basi antica et postica fere opposita, breviter decurrentia, ceterum ovato-oblonga, apice fere triplo angustiora quam basi, margine antico substricta recurva subintegerrima, margine postico arcuata versus basin ampliata, rotundata ibidemque cum folio opposito ad cristam erectam conniventia, longe spinosa, spinis sub 30 magnis approximatis angustis longe acuminatis recte patulis 7 cellulas longis basi 2–4 cellulas latis. Folii *cellulæ* 34 × 50 μ, trigonis majusculis; basales 34 × 80 μ, parietibus æqualiter incrassatis. *Perianthia* in caule terminalia, geminatim innovata, foliis parum longiora, plus duplo angustiora quam longa, antice late alata,

apice recte truncata ut in ala longe spinosa, spinis ut in folio sed magis confertis. *Folia floralia* caulinis simillima. *Andrœcia* in caule terminalia, longe spicata, spicis ad 2 vel 3 subfasciculatis erectis; bracteæ ad 16 jugæ, e basi longe saccata parum recurvo-patulæ, apice truncatæ et paucidenticulatæ.

Roraima, Ledge, 7500–8000 ft., *McConnell & Quelch*, 334/9 in part.

In *Plagiochila superba*, Wahlenb., the leaf-cells are much larger, the spines very stout, very much longer and less numerous. Lindenberg says (Monogr. Plag. p. 80) that Sieber had given him this species as coming from Australia; but this is a mistake of Sieber, who had not marked his packets and did not know on his return whence he had procured the plants; many errors of the same kind have been previously pointed out by me.

16. PLAGIOCHILA REMOTIFOLIA, Hampe & Gottsche in Linnæa, xxv. (1852), p. 340.

Roraima, Ledge, 7500–8000 ft., *McConnell & Quelch*, 334/3.

Pretty common in the West Indian Islands.

17. PLAGIOCHILA RUTILANS, Lindenb. Spec. Hep. ii. & iii. (Monogr. Hep. Gen. Plag.) p. 47.

Roraima, Ledge, 7500–8000 ft., *McConnell & Quelch*, 334/2 in part.

Common in Tropical America.

18. LEIOSCYPHUS FRAGILIS, J. B. Jack & Steph. in Hedwigia, xxxi. (1892), p. 20.

Summit of Roraima, *McConnell & Quelch*, 524 in part.

Also in New Granada.

19. LOPHOCOLEA BREUTELII, Gottsche, in Syn. Hep. p. 154.

Roraima, Ledge, 7500–8000 ft., *McConnell & Quelch*, 334/14 in part.

Common in the West Indian Islands.

20. MASTIGOBRYUM RORAIMENSE, Steph., n. sp. *Dioica*, mediocris, apice dilute flavo-virens, inferne brunneola, erecta, laxe intricata. *Caulis* ad 4 cm. longus, repetito furcatus, postice flagellis numerosis capillaceis instructus. *Folia* conferta, valde decurva, in plano subrecte patula, oblonga, parum falcata, antice parum ampliata, caulemque haud superantia, apice triplo angustiora quam basi, acute bidentula sinu lunato parum profundo vel truncata, angulis acutis. *Cellulæ* foliorum magnæ, apice 27 μ, trigonis maximis contiguis vel late confluentibus, medio infero multo majores, 37–56 μ, incrassatio parietum grosse trabeculata. *Amphigastria* caulina caule triplo fere latiora, imbricata, transverse inserta, late obcuneata, tertio supero inciso biloba, lobis similiter sed brevius bilobis; cellulæ amphigastriæ caulinis simillimæ, parum minores. *Folia floralia* quadrijuga, intima caulinis æquilonga, profundissime bifida, laciniis late lanceolatis, marginibus externis crenatis vel crenato-dentatis, internis subintegerrimis. *Amphigastrium florale* foliis suis æquale. *Perianthium* (juvenile) ore longe fimbriatum, ciliis triangulariter articulatis hic illic ramosis. Reliqua desunt.

Summit of Roraima, *McConnell & Quelch*, 523.

21. **Mastigobryum dissodontum**, Steph. n. nomen; *Bazzania bidens* var. *dissodonta*, Spruce, in Trans. Edinb. Bot. Soc. xv. (1885), p. 371.
Summit of Roraima, *McConnell & Quelch*, 532.
Found in Colombia.

22. **Mastigobryum portoricense**, Hampe & Gottsche in Linnæa, xxv. (1852), p. 348.
Roraima at 3500 ft., *McConnell & Quelch*, 545.
Common in the West Indian Islands and northern South America.

23. **Mastigobryum vincentinum**, Lehm. & Lindenb. Syn. Hep. p. 226.
Roraima, Ledge, 7500–8000 ft., *McConnell & Quelch*, 334/10, 15, & 16.
Common in the West Indian Islands.

24. **Mastigobryum Krugianum**, Steph. in Hedwigia, xxvii. (1888), p. 300.
Roraima, Ledge, 7000–8000 ft., *McConnell & Quelch*, 334/14 in part.
Found before in the island of Santo Domingo.

25. **Mastigobryum gracile**, Hampe & Gottsche, in Linnæa, xxv. (1852), p. 346.
Roraima, Ledge, 7500–8000 ft., *McConnell & Quelch*, 334/11 in part.
Known from different places in the West Indian Islands.

26. **Micropterygium grandistipulum**, Steph., n. sp. *Sterilis*, minor, dilute brunnea vel flavo-rufescens, muscicola, valde intricatim cæspitans. *Caulis* tenuis, ad 2 cm. longus, irregulariter ramosus. *Folia* conferta, decurvula, semiamplexicaulia, ex angusta basi ovato-oblonga, longe acuminata, apice abrupte attenuata ibidemque paucidenticulata vel integerrima. *Folii* lobulus posticus integerrimus, brevi spatio (ad $\frac{1}{4}$) carinatim coalitus, folium subinde oblique percurrens, attenuatus, longe sub folii apice desinens. *Cellulæ* foliorum læves, $8 \times 12\ \mu$, basales $8 \times 17\ \mu$, subrectangulatæ, maxime æqualiterque incrassatæ. *Amphigastria* magna, imbricata, foliis parum breviora, transverse inserta, plana, integerrima, medio infero fere circularia, superne abrupte angustata, lanceolata, acuta.
Roraima, Ledge, 7500–8000 ft., *McConnell & Quelch*, 334/14 in part.

There is not a species of this genus which does not have some of its leaves merely conduplicate, the wing being entirely wanting; where the latter is developed it is part of the antical lobe, which can easily be observed if a transverse cut of the leaf is made; the same occurs sometimes in *Scapania*, and is best developed in *Schistochila*.

27. **Micropterygium pterygophyllum**, Spruce, in Trans. Edinb. Bot. Soc. xv. (1885), p. 384. *Jungermannia pterygophylla*, Nees, in Mart. Fl. Bras. vol. i. pars prior, Algæ, Lichenes, Hepaticæ, p. 377.
Summit of Roraima, *McConnell & Quelch*, 530 in part.
Common in Tropical America.

28. **Lepidozia commutata**, Steph. in Hedwigia, xxvii. (1888), p. 293.
Summit of Roraima, *McConnell & Quelch*, 521.
Very common in the West Indian Islands.

29. **Lepidozia laxepinnata**, Spruce, in Trans. Edinb. Bot. Soc. xv. (1885), p. 360.
Roraima at 3500 ft., *McConnell & Quelch*, 552.

An Andine species not found anywhere else before.

30. **Schisma juniperinum**, Nees, Hep. Eur. iii. p. 575. *Jungermannia juniperina*, Sw. Veg. Ind. Occ. iii. p. 1855.

Summit of Roraima, *McConnell & Quelch*, 522, 528, 538, 539; in the last associated to *Jamesoniella colorata*, Spruce.

Very common in Tropical America.

31. **Schisma pensilis**, Steph., n. nomen. *Sendtnera pensilis*, Taylor, in Hook. Lond. Journ. Bot. v. (1846), p. 372.

Roraima, Ledge, 7500–8000 ft., *McConnell & Quelch*, 334/2 in part.

A pretty rare Andine species.

32. **Schisma Durandii**, Steph., n. sp. *Sterilis* longissima, gracilis, lurida, longe lateque stratificata et dense cæspitosa. *Caulis* ad 20 cm. longus, fragilis, simplex superne sæpe fasciculatim ramosus, apice breviter circinatus, postice flagellifer, flagellis brevibus approximatis parvifoliis. *Folia* pro planta parva, triplo longiora quam lata, ad $\frac{2}{3}$ bifida, laciniis lanceolatis apice longe setaceis valde hamatis valdeque divergentibus. *Cuticula grosse verrucosa.* *Cellulæ* foliorum subapicales $17 \times 25\ \mu$, parietibus longioribus et marginalibus trabeculatim incrassatis. Cellulæ basales $25 \times 70\ \mu$, oblongo-hexagonæ, trigonis magnis sæpe trabeculatim confluentibus. *Flagellorum* folia multoties minora, ovato-oblonga, laxe accumbentia, porrecta, ad $\frac{2}{3}$ bifida, laciniis late lanceolatis vix setaceis.

Roraima, Ledge, 7500–8000 ft., *McConnell & Quelch*, 334/2, 334/11 & 334/14, all in part.

This plant has been found before by Pittier in the higher mountains of Costa Rica.

33. **Schisma subdentatum**, Steph., n. sp. *Sterilis*, mediocris, fusco-purpurascens, optime nitens, densissime depresso-cæspitosa. *Caulis* ad 6 cm. longus, simplex vel furcatus, furcis divergentibus. *Folia* confertissima, maxime decurvo-hamata, angusta, plus 3-plo longiora quam lata, ad $\frac{2}{3}$ bifida, laciniis parum divergentibus, longe acuminatis, acutis. *Cellulæ* foliorum subapicales $17 \times 25\ \mu$, parietibus longioribus valde incrassatis; incrassatio marginalis, præcipue *ad angulos cellularum, grosse nodulose- vel subdentatim prominula.* *Cellulæ* basales folii longe hexagonæ, $25 \times 68\ \mu$, parietibus longioribus maxime trabeculatim incrassatis.

Roraima, Ledge, 7500–8000 ft., *McConnell & Quelch*, 334/1.

34. **Trichocolea sphagnoides**, Steph., n. nomen. *Leiomitra sphagnoides*, Spruce, in Trans. Edinb. Bot. Soc. xv. (1885), p. 350.

Roraima, Ledge, 7500–8000 ft., *McConnell & Quelch*, 334/9 in part, 11 in part, and 13.

Andes of Quito.

35. SCAPANIA PORTORICENSIS, Hampe & Gottsche, in Linnæa, xxv. (1852), p. 342.
Summit of Roraima, *McConnell & Quelch*, 573.

Not rare in the West Indian Islands, and found by Spruce also on the top of Mount Abitagua, 2000 m. (his *Scapania splendida*).

36. PLEUROZIA PARADOXA, Steph., n. nomen.—*Physiotium paradoxum*, J. B. Jack, in Hedwigia, xxvii. (1886), p. 85.
Summit of Roraima, *McConnell & Quelch*, 543.
Known before from Pasto, collected by F. C. Lehmann.

37. HARPALEJEUNEA TENAX, Steph., n. sp. *Sterilis*, minor, fusco-olivacea, rigida, dense cæspitosa. *Caulis* ad 15 mm. longus, capillaceus, parum ramosus. *Folia* remotiuscula, caule vix latiora, parum patula, cauli fere parallela, valde concava, in plano cordiformia, tertio supero abrupte angustata acuminata acuta vix incurva, *lobulo* duplo angustiore, valde inflato, in acumen folii attenuato. *Cellulæ* foliorum parvæ, ad 12 μ, trigonis late confluentibus. *Amphigastria* parva, transverse inserta, caulem vix superantia subrotunda, appressa, integerrima.
Roraima, Ledge, 7500–8000 ft., *McConnell & Quelch*, 334/.

A much reduced form, rigid and evidently well adapted to a dry climate, the leaves being very small, little projecting from the stem, the cell-walls very thick. This plant is almost unique in the great number of species of *Lejeunea*, which always live in damp and well sheltered places, and disappear where a dry atmosphere can reach them.

38. FRULLANIA MIRABILIS, J. B. Jack & Steph. in Hedwigia, xxxi. (1892), p. 15.
Summit of Mount Roraima, *McConnell & Quelch*, 510.
Collected before by Wallis in New Granada, near Antioquia.

39. FRULLANIA ATRATA, Nees, in Syn. Hep. p. 463. *Jungermannia atrata*, Sw. Prodr. Fl. Ind. Occ. p. 144.
Summit of Roraima, *McConnell & Quelch*, 535.
Very common in Tropical America.

40. FRULLANIA LONGICOLLIS, Lindenb. & Gottsche, in Syn. Hep. p. 783.
Summit of Roraima, *McConnell & Quelch*, 335.
An Andine species, found also in Mexico.

IV. THALLOPHYTA.

FUNGI. By G. Massee, F.L.S.

Phoma Psammisiæ, Massee, n. sp. Maculæ nullæ; perithecia epidermide tecta, gregaria, 500 μ diam., atra, ostiolo papillato pertusa; sporæ ellipticæ, 2-guttulatæ, 10–11 × 3 μ.

Spots absent; perithecia gregarious, covered by the grey raised epidermis, lenticular, averaging 500 μ in diameter, black, glabrous; ostiolum minute, papillate; texture parenchymatous, dense, olive; spores hyaline, elliptical, ends obtuse with two minute polar guttulæ, 10–11 × 3 μ.

On dead branch of *Psammisia coriacea*, N. E. Brown. Summit of Roraima, *McConnell & Quelch.*

Allied to *P. stictica*, Berk. et Broome.

Echinobotryum roseum, Massee, n. sp. Mycelium tenuissimum vix manifestum, album; hyphæ fertiles erectæ, septatæ, hyalinæ, 4 μ crassæ. Conidia in apicibus hypharum fertilium densius aggregata, sessilia, fusoidea, 15–17 × 6 μ, roseo-tincta.

Sterile hyphæ prostrate, hyaline, septate, branched, about 4 μ thick, loosely interwoven into a very thin white layer; fertile hyphæ erect, septate, simple, hyaline, 4 μ thick, apex minutely nodulose and producing numbers of sessile spindle-shaped, pale rose-coloured conidia measuring 15–17 × 6 μ.

Parasitic on *Octomeria parvifolia*, Rolfe. Summit of Roraima, *McConnell & Quelch*, 696.

Allied to *E. læve*, Sacc., from which the present differs in the form and colour of the spores.

Stemphylium ericoctonum, A. Br. & de Bary, Krankh. d. Pflanz. (1854), p. 18, tab. 2.

On living branches of *Leitgebia Imthurniana*, Oliver. Summit of Roraima, *McConnell & Quelch.*

Europe.

Macrosporium ramulosum, Sacc. Fung. Ital. tab. 854 (1881).

On fading leaves of *Tofieldia Schomburgkiana*, Oliver. Summit of Roraima, *McConnell & Quelch.*

Europe, and in the Andes of Colombia.

Capnodium fibrosum, Berk. in Hook. Fl. Nov. Zel. ii. (1855), p. 209.

Forming a black bristly pile on living twigs of *Psammisia*. Summit of Roraima, *McConnell & Quelch*, 662.

N. Zealand.

Rhipidonema membranaceum, Sacc. Syll. vi. (1888), p. 688.

On bark. Roraima, 8000 ft., *McConnell & Quelch*, 508, 526.

Amazon Valley; Marianne Islands.

LICHENES. By G. MASSEE, F.L.S.

SPHÆROPHORON COMPRESSUM, Ach. Meth. Lich. (1803), p. 135.
On stones. Summit of Roraima, *McConnell & Quelch*, 506.
Cape Horn; Chili; W. Indies; Europe; India; Ceylon.

CLADONIA RANGIFERINA, Hoffm. Flor. Germ. (1795), p. 114.
On the ground. Summit of Roraima, *McConnell & Quelch*, 507 & 520.
Cosmopolitan.

PARMELIA DICTYORHIZA, Massee, n. sp. Thallus membranaceo-cartilagineus, substellatus, repetito dichotomo-laciniatus, cretaceus, subtus niger, spongiosus. Apothecia ignota.

Thallus thin, cartilaginous, radiating from a centre in an irregularly stellate manner, repeatedly dichotomously divided, chalk-white above, black and spongy below, the spongy stratum composed entirely of closely septate brown hyphæ 11–12 μ thick, arranged in the form of an irregular network. Apothecia unknown. Laciniæ about 2 mm. wide.

On the ground. Summit of Roraima, *McConnell & Quelch*, 53.

Allied to *P. hypotropa*, Nyl., but separated from this and every other described species in the reticulate structure of the spongy lower surface of the thallus.

PARMELIA PERFORATA, Ach. Lich. Univers. (1810), p. 410.
On branches. Summit of Roraima, *McConnell & Quelch*, 503 & 513.
Central and N. America; Central Africa; Polynesia.

ALECTORIA OCHROLEUCA, Nyl. Prod. Lich. (1857), p. 46.
On branches. Summit of Roraima, *McConnell & Quelch*, 504.
Mexico; United States; Europe; Himalaya; Japan; Australia.

EXPLANATION OF THE PLATES.

PLATE 1.

Ilex apicidens. (Figs. 1 to 6.)

Figs. 1 & 2. Branches with lax and dense inflorescences, natural size.
Fig. 3. Flower, × 4.
4. Flower with petals and stamens removed, × 4.
5. Stamen, dorsal view, × 4.
6. Stamen, front view, × 4.

Cyrilla brevifolia. (Figs. 7 to 16.)

Figs. 7 & 8. Two branches, natural size.
Fig. 9. Fragment of a raceme with one flower, × 5.
10. Sepal, seen from within, × 7.
11. Petal, seen from within, × 7.
12. Stamens, front and side views, × 7.
13. Flower, with the outer parts removed to show the ovary, × 7.
14. A trifid stigma, × 7.
15. Ovary, longitudinal section, × 12.
16. Ovaries, transverse sections, × 12. The ridges on the ovaries may be due to shrinkage, but they are represented as seen after long boiling.

PLATE 2.

Macairea aspera.

Fig. 1. Branch, natural size.
2. Fragment of leaf, upper surface, × 4.
3. Flower, with the petals and six stamens removed, × 5.
4. Petal, × 5.
5. Transverse section through the calyx-tube and ovary, × 5.
Figs. 6 & 7. Long and short stamens from another specimen (no. 24, *McConnell & Quelch*), × 5.

PLATE 3.

Passiflora Quelchii.

Fig. 1. Branch, natural size.
2. Inflorescence, natural size.
3. Longitudinal section of a flower, × 2.
4. Filament of the lower corona, × 5.

PLATE 4.

Henriquezia Jenmani.

Fig. 1. Leaf and inflorescence, natural size.
2. Flower, with the corolla removed, natural size.
3. Corolla, laid open, natural size.
4. Ovary after the sepals have fallen, × 3.
5. Ovary, longitudinal section, × 3.
6. Ovary, transverse section, × 3.

PLATE 5.

Didymochlamys Connellii. (Figs. 1 to 9.)

Fig. 1. Part of a plant seen from above, natural size.
2. Part of a plant seen from beneath, natural size.
3. Inflorescence, with one bract removed, × 2.
4. Flower with 2 sepals and the corolla removed, × 5.
5. Corolla, laid open, × 2.
6. A lobe of the corolla, × 4.
7. Ovary, with glands and calyx-lobes, longitudinal section, × 5.
8. Ovary, longitudinal section, showing placentas, × 5.
9. Ovary, transverse section, × 5.

Chalepophyllum Connellii. (Figs. 10 to 17.)

Figs. 10 & 11. Two branchlets showing the range of variation in different specimens, natural size, but the stems are not stout enough.
Fig. 12. Calyx and ovary, natural size.
13. Part of a corolla laid open, natural size.
14. Stamens, dorsal and front views, × 2.
15. Ovary, longitudinal section, × 4.
16. Ovary, transverse section, × 4.
17. Ovule, × 12.

PLATE 6.

Retiniphyllum laxiflorum.

Fig. 1. Branch, natural size.
2. Flower, × 2.
3. Apex of a pedicel, × 5.
4. Longitudinal section through the lower part of a flower, × 5.
5. Three views of a stamen, × 5.
6. Ovary, transverse section, × 5.
7. Longitudinal section of an ovarian cell, × 20.
8. Transverse section of an ovarian cell, × 20.
9. Oblique dorsal view of the cap-shaped placenta and ovules, × 20.
10. Oblique front view of the placenta and one ovule, the other ovule removed, × 20.
11. Fruit, × about 2½.
12. Fruit, transverse section, × 3.

PLATE 7.

Heterothalamus densus. (Figs. 1 to 7.)

Fig. 1. Branch of a male plant, natural size.
2. Branch of a female plant, natural size.
3. Involucre of a male head of flowers, × 5.
4. Involucre of a female head of flowers, × 5.
5. Male floret, × 5.
6. Bract from the receptacle of a female head, × 5.
7. Female floret, × 5.

Quelchia conferta. (Figs. 8 to 14.)

Figs. 8 & 9. Two branches, showing variation in the length of the peduncles, natural size.
Fig. 10. A flower-head, × 4.
11. A flower-head, longitudinal section, × 4.
12. Corolla laid open, with four stamens removed, × 4.
13. Anthers, dorsal view, with three filaments cut off, × 4.
14. Fruit, × 2.

PLATE 8.

Stiftia Connellii.

Fig. 1. Branch, natural size.
2. Bract from the receptacle, × 2.
3. Floret, with part of the pappus removed, × 2.
4. Stamens, × 2.
5. Apex of style, × 2.

PLATE 9.

Bonyunia minor. (Figs. 1 to 5.)

Fig. 1. Branch, with flowers and fruit, natural size.
2. Branchlet of an inflorescence, × 4.
3. Part of a corolla laid open, × 4.
4. Longitudinal section of a flower, with the corolla removed, × 4.
5. Transverse section of an ovary, × 12.

Lisianthus Quelchii. (Figs. 6 to 9.)

Figs. 6 & 7. Portions of different plants, natural size.
Fig. 8. Flower with two sepals and the corolla removed, natural size after boiling.
9. Corolla laid open, natural size.

PLATE 10.

Utricularia Connellii. (Figs. 1 to 6.)

Fig. 1. Three entire plants, natural size.
2. Part of inflorescence, showing bract and bracteoles, × 5.
3. Flower, × 2.
4. Calyx, dorsal view, × 5.
5. Stamens, × 5.
6. Pistil, × 10.

Utricularia concinna. (Figs. 7 to 11.)

Fig. 7. Three entire plants, natural size.
8. Inflorescence, × 3.
9. Flower, viewed from above, with the dorsal sepal turned back, × 3.
10. Stamens, × 10.
11. Pistil, × 10.

Utricularia Quelchii. (Figs. 12 to 16.)

Fig. 12. Two entire plants, natural size.
13. Bract, bracteoles, and calyx, natural size.
14. Corolla, natural size.
15. Stamens, × 5.
16. Pistil, × 5.

PLATE 11.

Utricularia roraimensis. (Figs. 1 to 4.)

Fig. 1. Group of plants, natural size.
2. Part of a raceme, with the corolla removed, × 5.
3. Corolla, × 5.
4. Stamen, × 10.

Genlisea roraimensis. (Figs. 5 to 12.)

Fig. 5. Plant, natural size.
6. Fragment of the base of a stem, with leaf (+ +), false roots, and an imperfect utricle standing erect among the leaves, × 10.
7. Perfect utricle, × 5.
8. Imperfect utricle, transition form between the ordinary false root and the perfect utricle, × 5. This form has a very minute pore at the apex.
9. Imperfect utricle, erect form, × 5.
10. Part of a raceme, with the corolla removed, × 5.
11. Corolla, × 5.
12. Stamen, × 5.

PLATE 12.

Brocchinia reducta.

Fig. 1. Rosette of leaves, natural size.
2. Inflorescence, natural size.
3. Flower, with a sepal and two petals removed, × 5.
4. Sepal, × 5.
5. Petal, × 5.
6. Style and stigmas, × 5.
7. Transverse section of unripe capsule, seeds not shown, × 5.
8. Seed, × 5.

PLATE 13.

Connellia Augustæ.

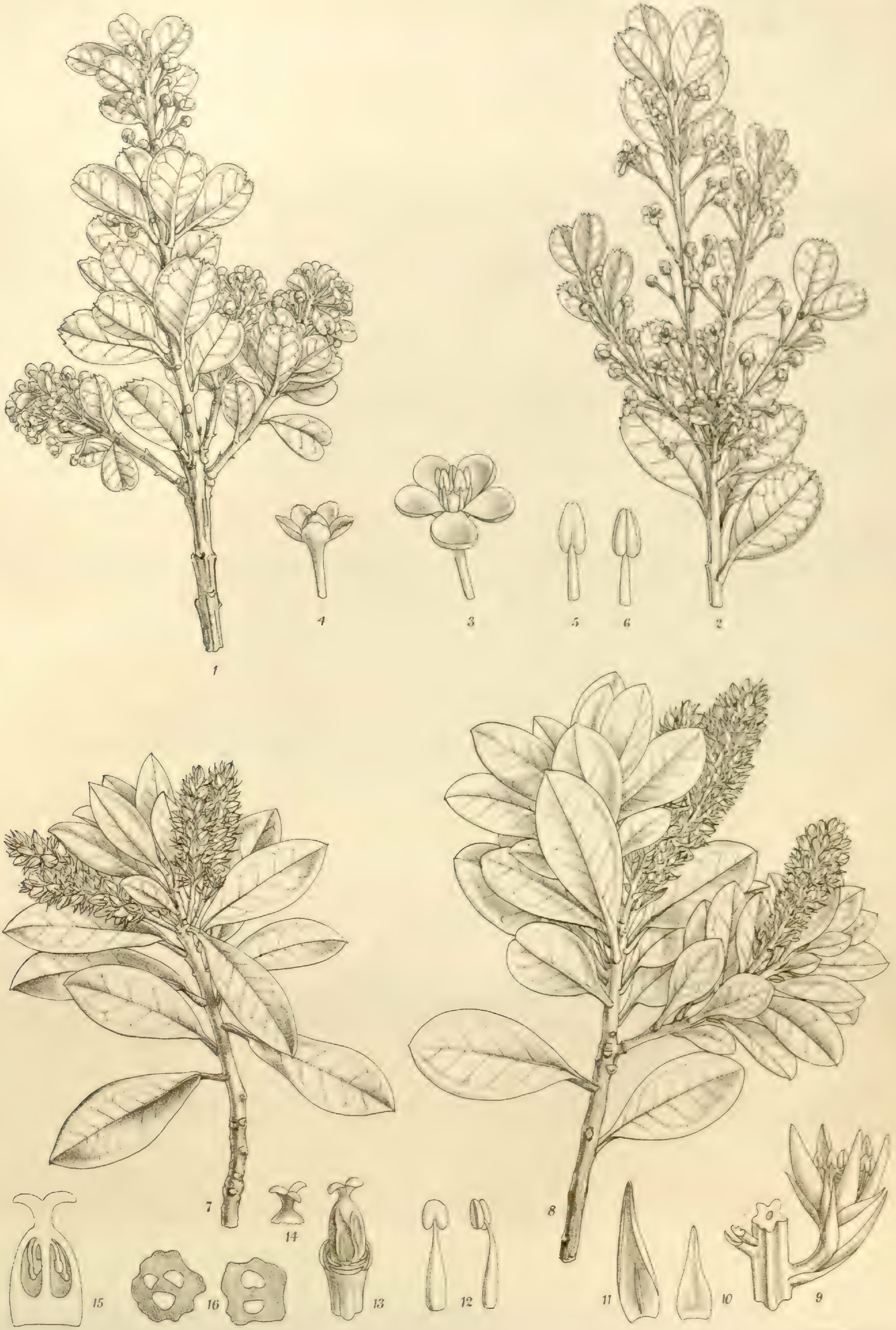
Fig. 1. Leaf, natural size.
2. Inflorescence in flower, natural size.
3. Inflorescence in fruit, natural size.
4. Sepal, natural size.
Petal, natural size.
6. Ovary, the other parts of the flower being removed, natural size.
7. Ovule, × 30.
8. Ripe fruit and bracteole, natural size.
9. Seeds, × 10.

Figs. 1, 3, 8, & 9 are from McConnell & Quelch's specimen, the rest are from Schomburgk's specimen.

PLATE 14.

Connellia Quelchii.

Figs. 1 & 2. Plants natural, size.
Fig. 3. A large tuft of leaves, natural size.
4. A leaf, tomentose on the back, natural size.
5. Sepal, × 2.
6. Petal, × 2.
7. Ovary, × 2.
8. Young fruit, × 2.
9. Transverse section of an ovary, × 5.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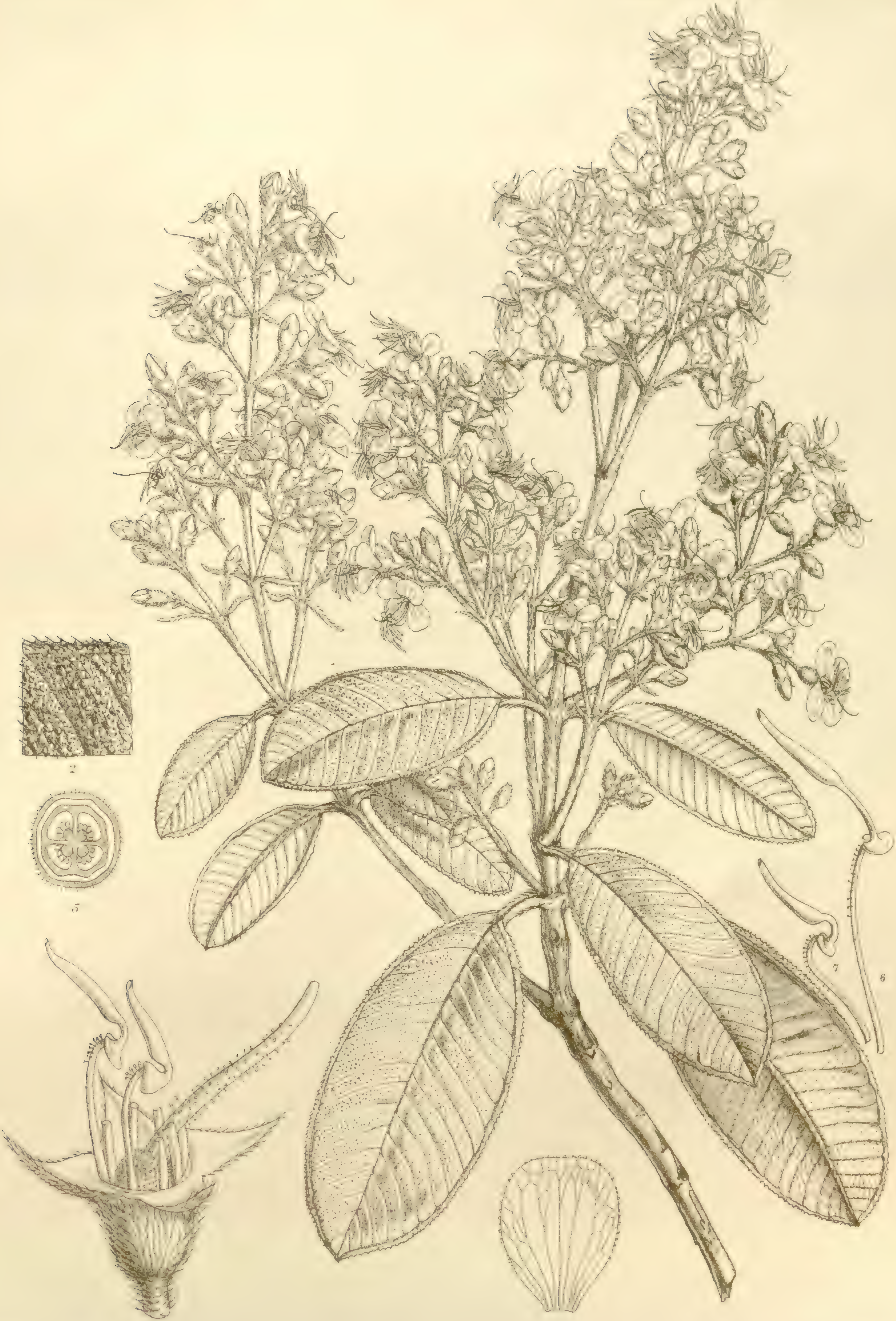
J.N.Fitch del. et lith. N.E.Brown anal.

W.B.Hemsley dir.

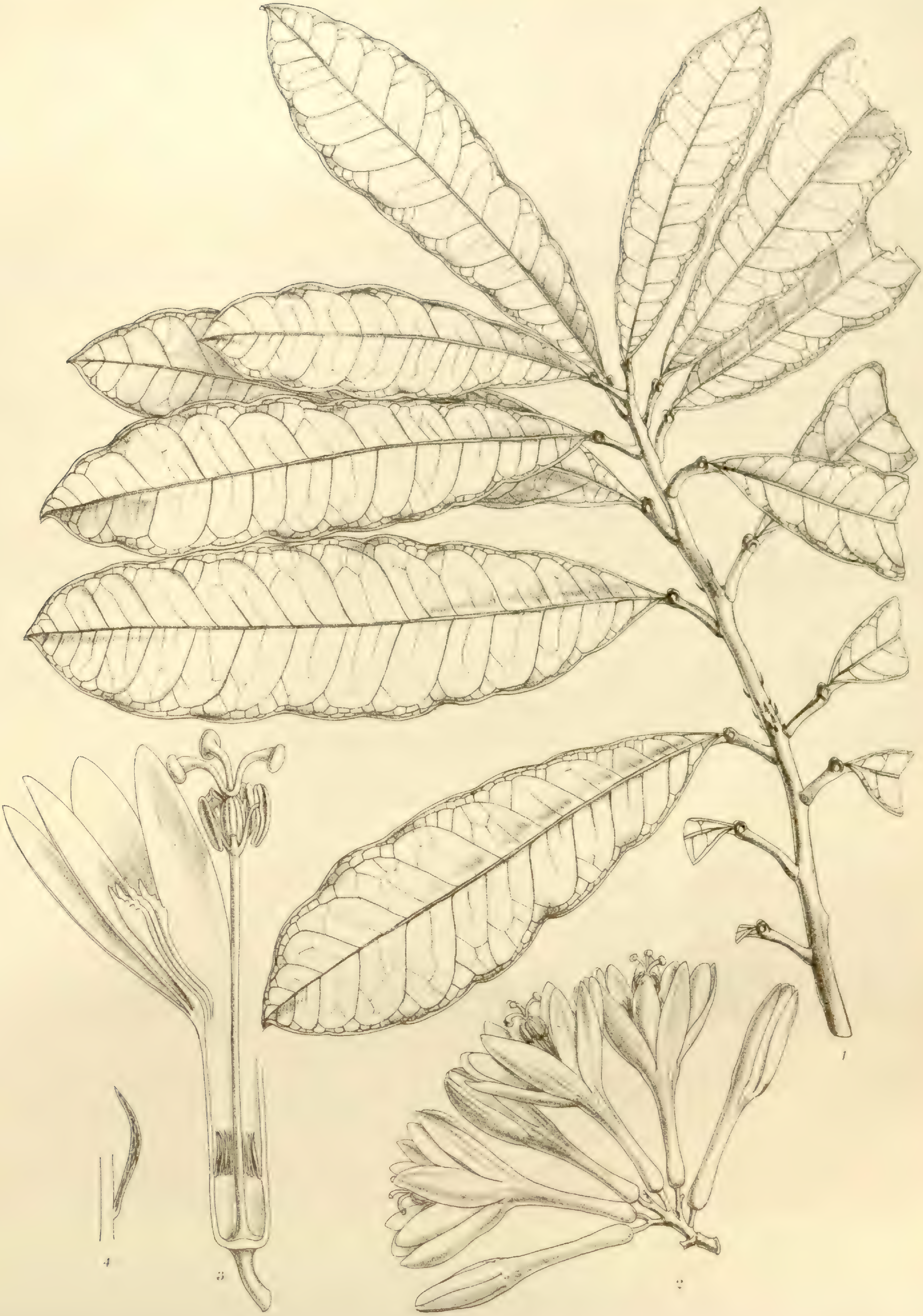
1-6 ILEX APICIDENS, N.E.Brown. 7-16 CYRILLA BREVIFOLIA, N.E.Brown.



J.N.Fitch del. et lith. N.E.Brown anal.

W.B.Hemsley dir.

MACAIREA ASPERA, N.E.Brown.

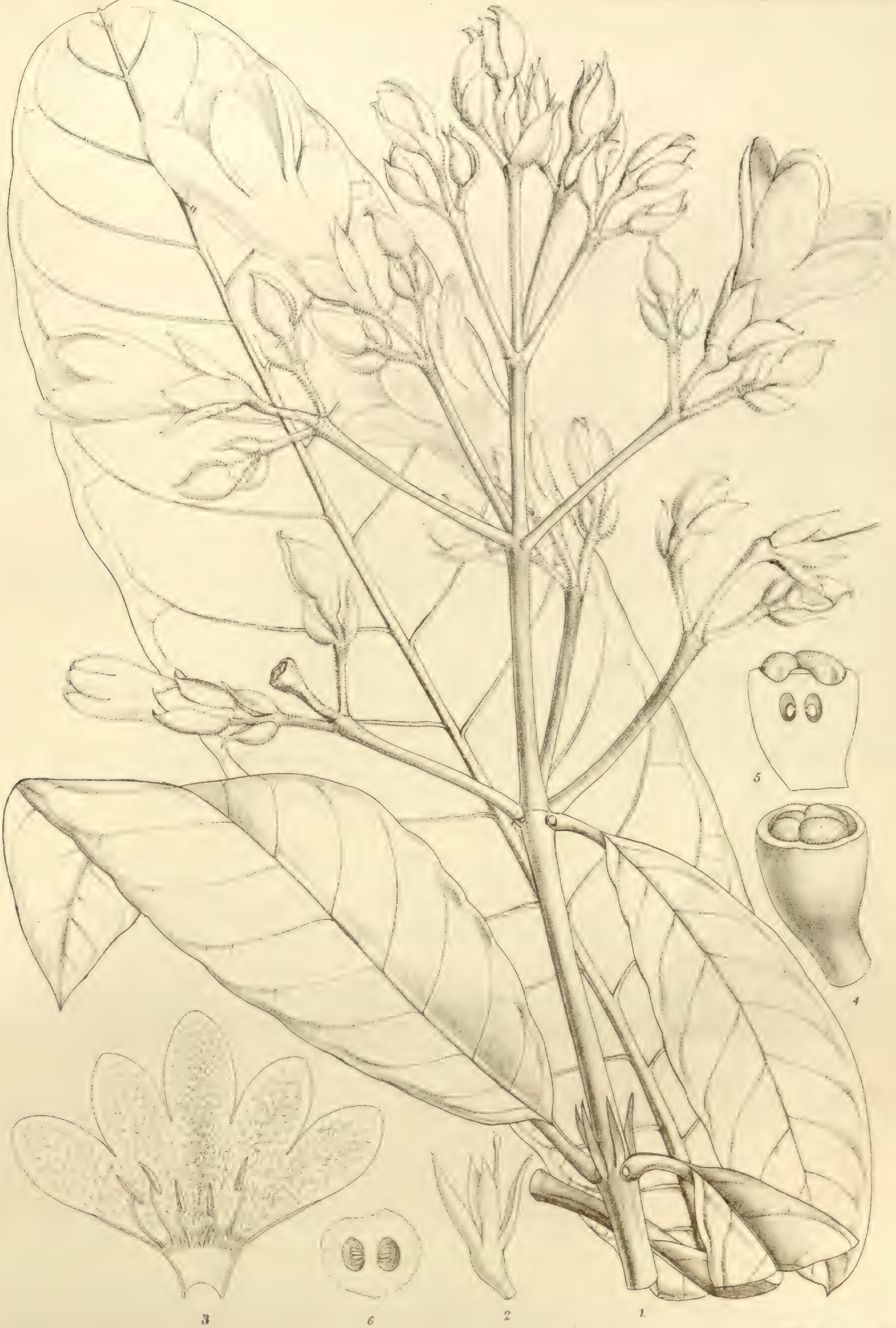


J.N.Fitch del. et lith. N.E.Brown anal.

W.B.Hemsley dir.

PASSIFLORA QUELCHII, N.E.Brown.

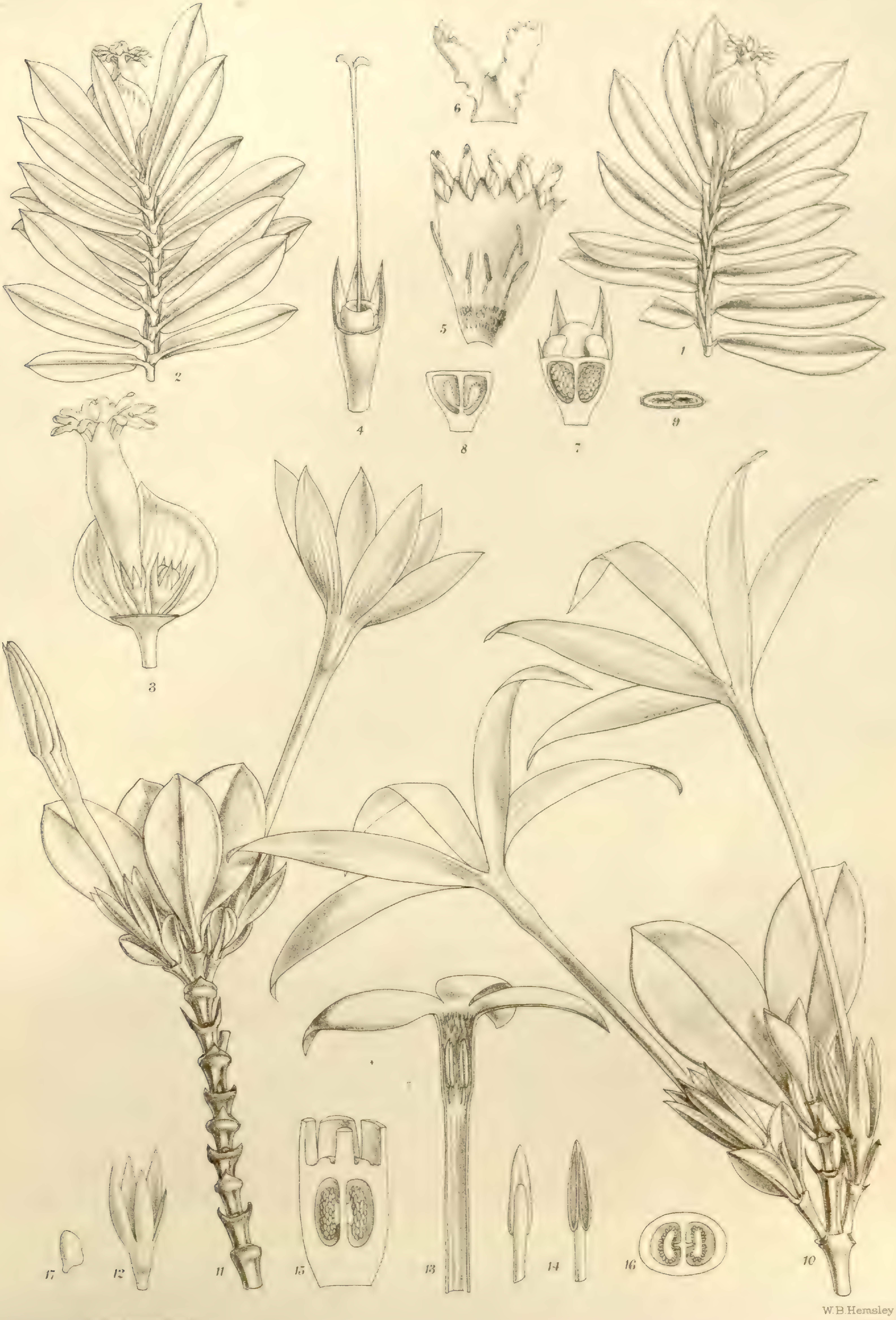
Mc Connell & Quelch.



J. N. Fitch del. et lith. N. E. Brown anal.

W. B. Hemsley dir.

HENRIQUEZIA JENMANI, K. Schum.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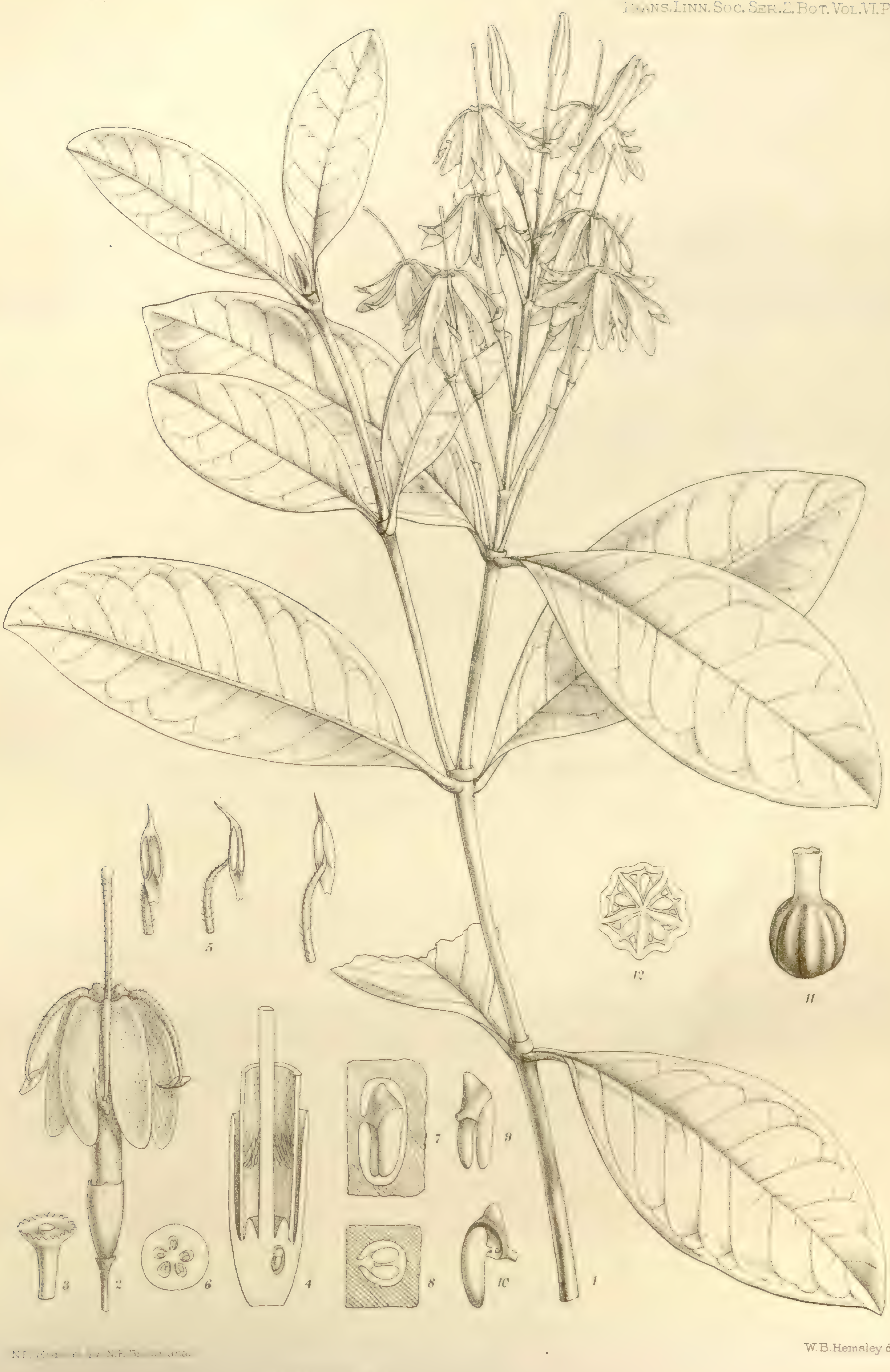
W. B. Hemsley dir.

J. N. Fitch del et lith. N. E. Brown anal.

1-9 DIDYMOCHLAMYS CONNELLII, N.E.Brown. 10-17 CHALEPOPHYLLUM SPECIOSUM, N.E.Brown.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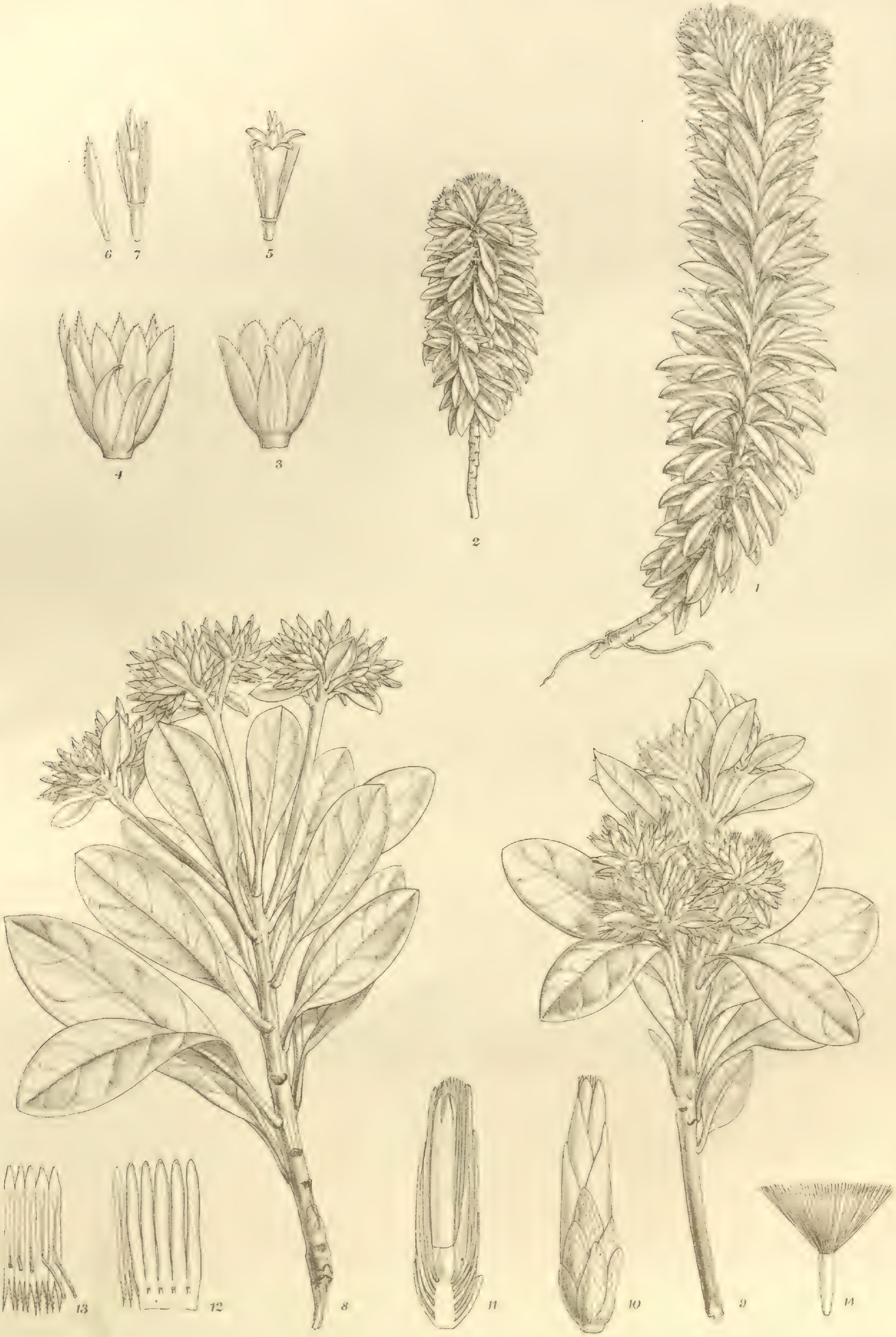
W.B.Hemsley dir.

RETINIPHYLLUM LAXIFLORUM, N.E. Brown.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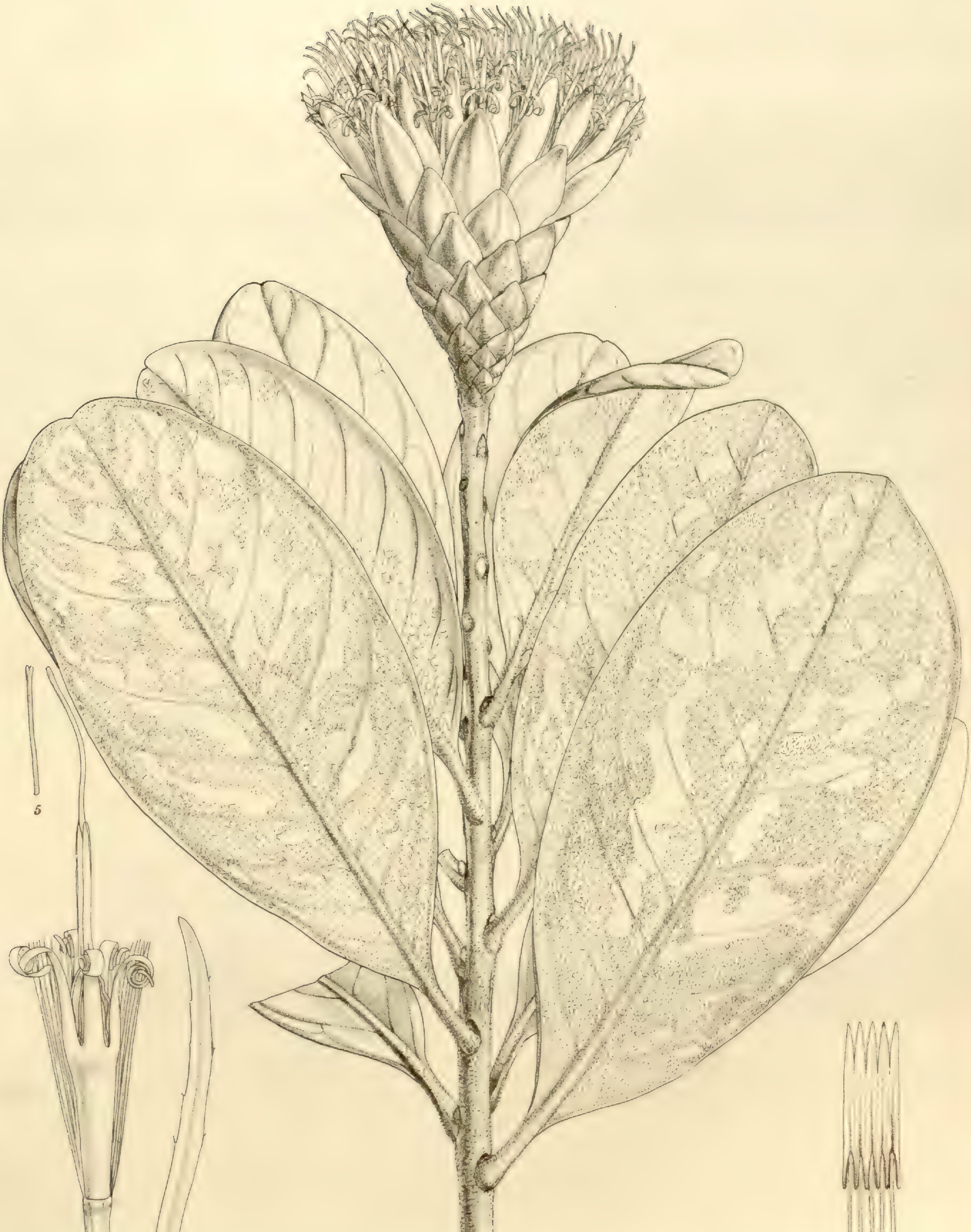
J. N. Fitch del. et lith. N. E. Brown anal. W. B. Hemsley dir.

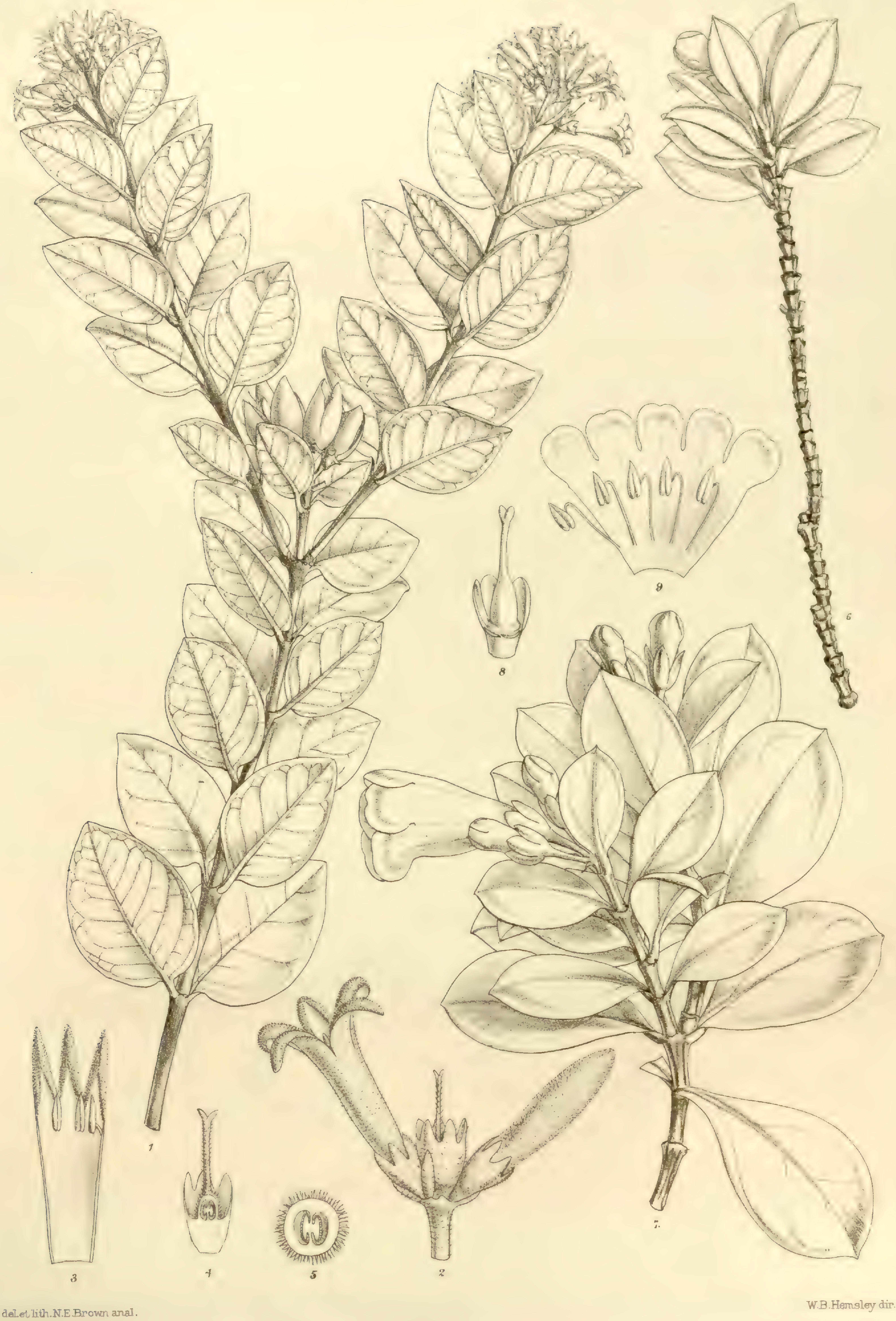
1-7 HETEROTHALAMUS DENSUS, N.E.Br. 8-14 QUELCHIA CONFERTA, N.E.Br.



J.N.Fitch del. et lith. N.E.Brown anal.

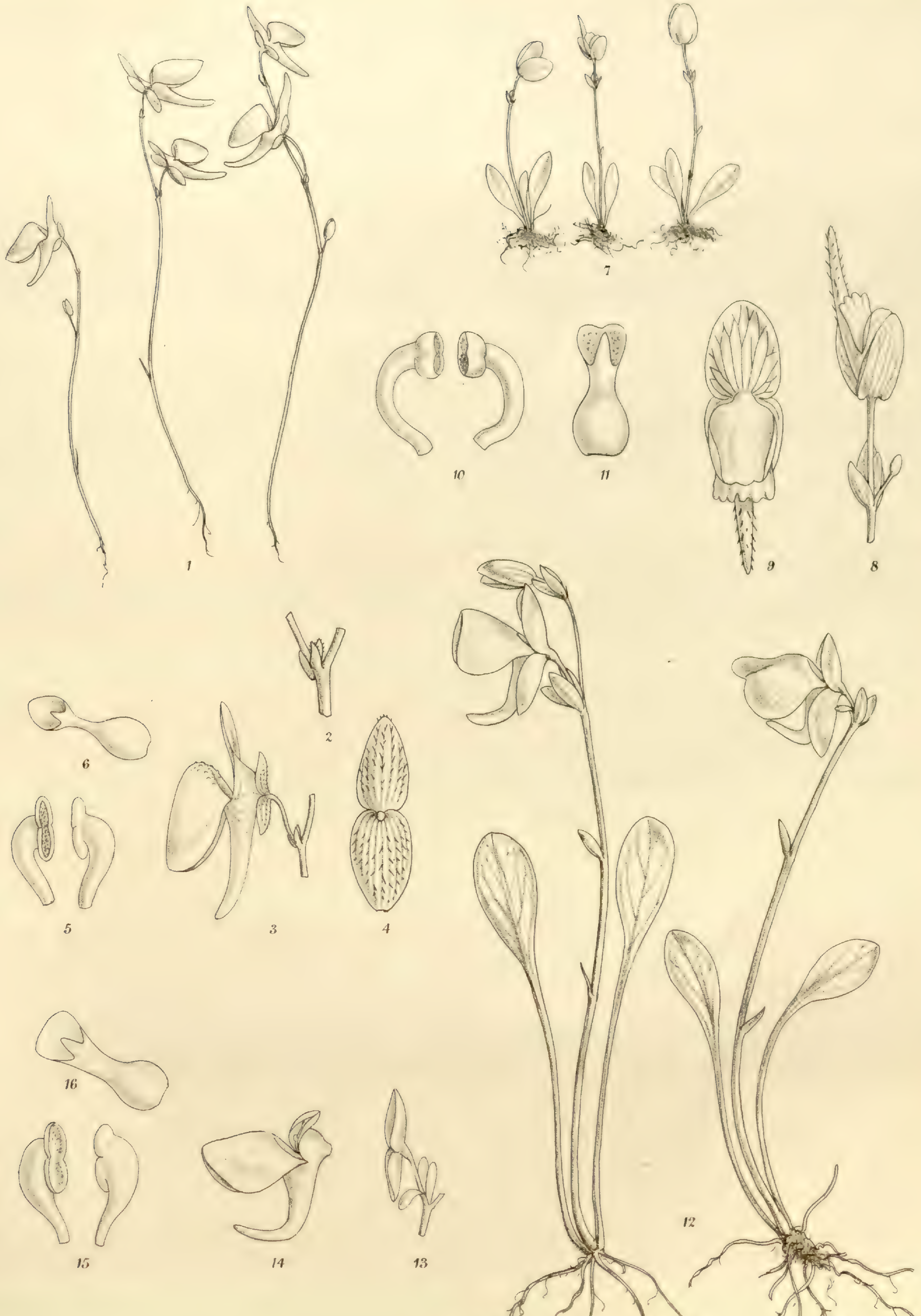
W.B.Hemsley dir.

STIFTIA CONNELLLII, N.E.Brown.



J.N. Fitch del. et lith. N.E. Brown anal. W.B. Hemsley dir.

1-5. BONYUNIA MINOR, N.E. Brown. 6-9, LISIANTHUS QUELCHII. N.E. Brown.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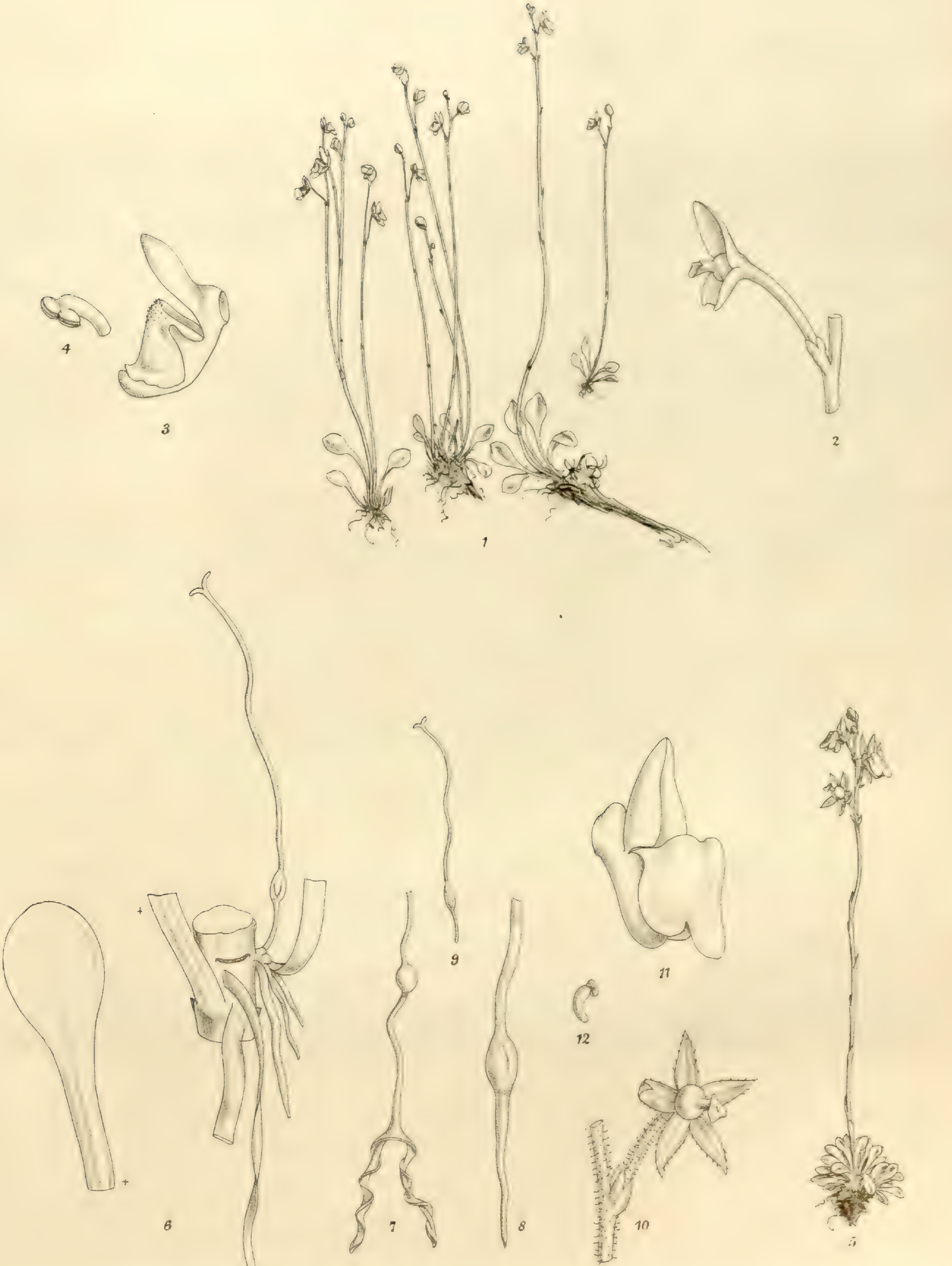
J.N.Fitch del. et lith. N.E.Brown anal.

W.B.Hemsley dir.

1-6 UTRICULARIA CONNELLII, N.E.Brown. 7-11 U. CONCINNA, N.E.Brown. 12-16 U. QUELCHII N.E.Brown.

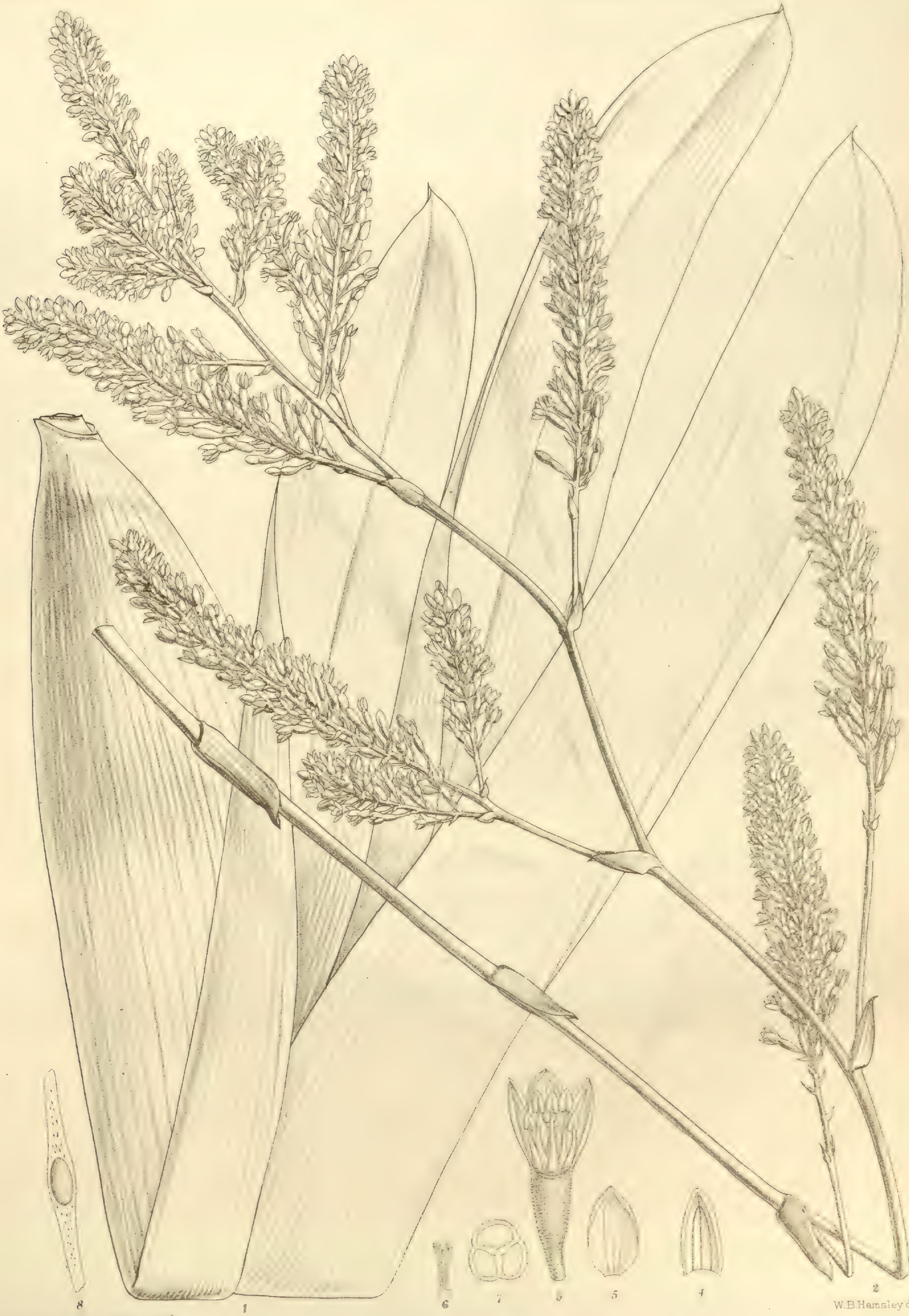


J.N.Fitch del. et lith. N.E.Brown anal.

W.B. Hemsley dir.

1-4 UTRICULARIA RORAIMENSIS, N.E.Brown. 5-12 GENLISEA RORAIMENSIS. N.E.Brown.

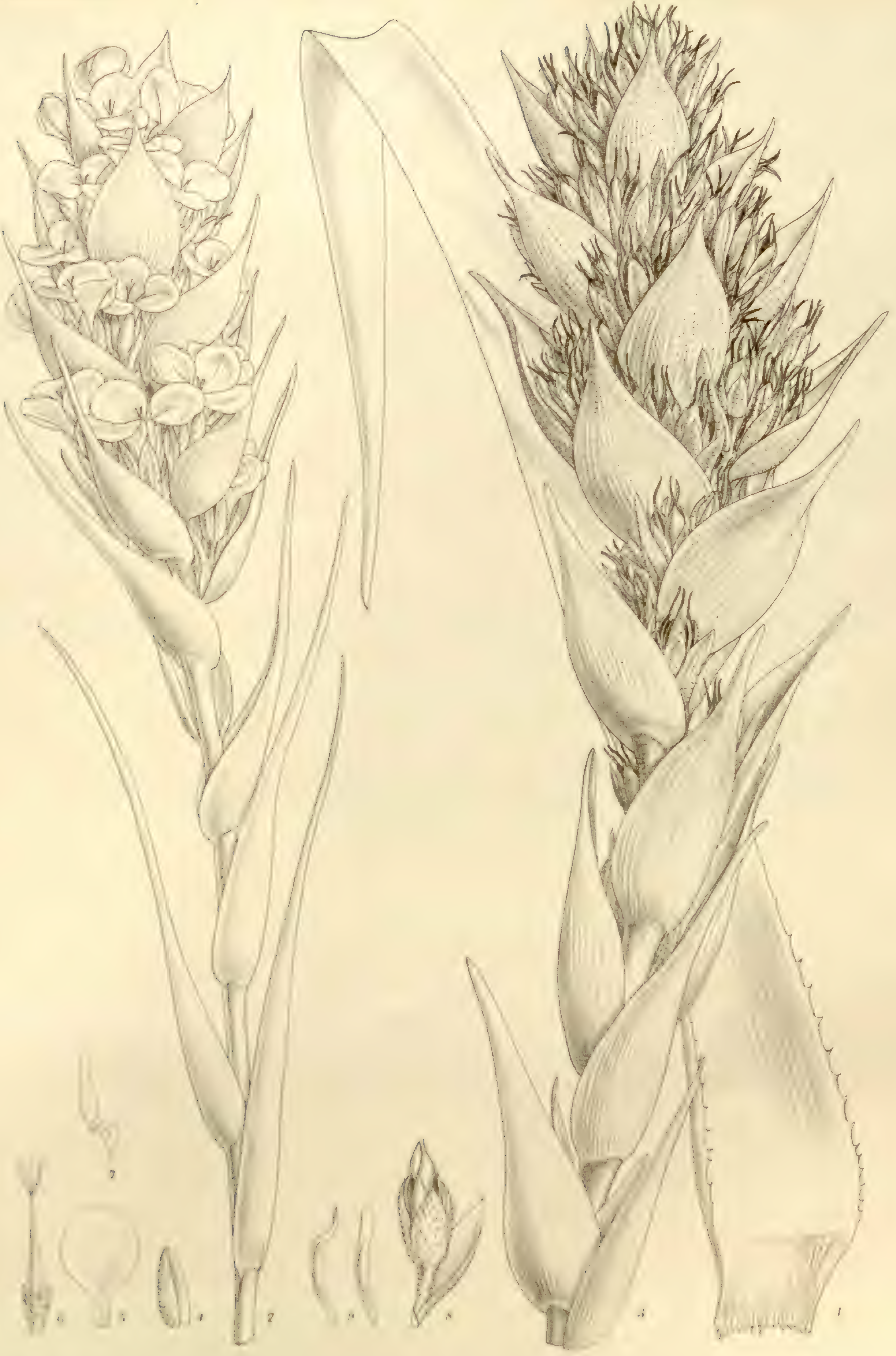
Mc Connell & Quelch



J.N.Fitch del. et lith N.E.Brown anal

W.B.Hemsley dir

BROCCHINIA REDUCTA, Baker.

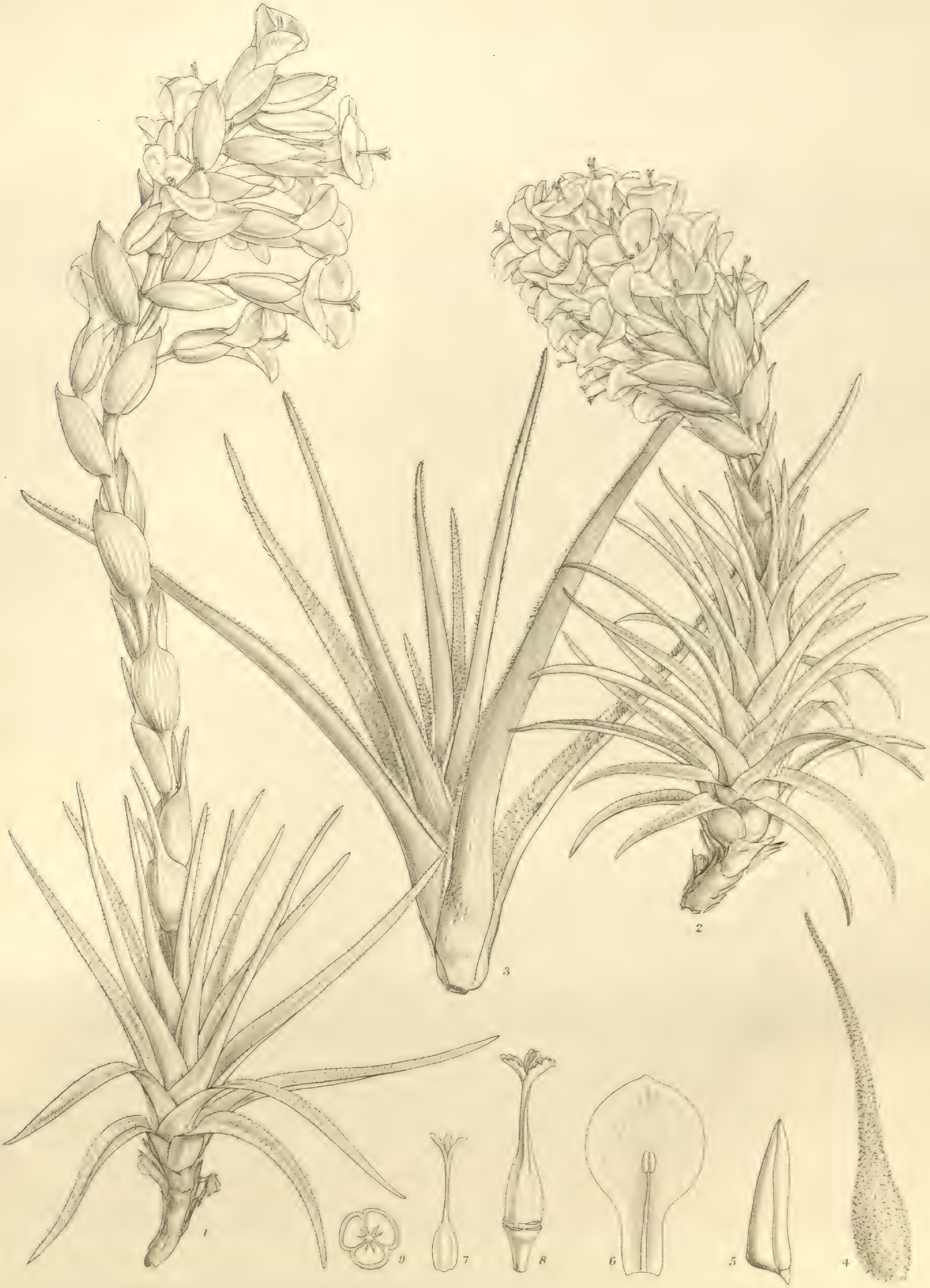


J.N.Fitch del.et lith. N.E.Brown anal. W.B.Hemsley dir.

CONNELLIA AUGUSTAE, N.E. Brown.

Mc Connell & Quelch

TRANS. LINN. SOC. SER. 2. BOT. VOL. VI. PL. 14.



J.N.Fitch del. et lith. N.E.Brown anal.

W. B. Hemsley dir.

CONNELLIA QUELCHII, N.E.Br.

LINNEAN SOCIETY OF LONDON.

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THE
TRANSACTIONS
OF
THE LINNEAN SOCIETY OF LONDON.

CONTRIBUTIONS TO THE COMPARATIVE ANATOMY OF THE CYCADACEÆ.

BY

W. C. WORSDELL, F.L.S.

NATURÆ
DISCERE
MORES

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September 1901.

II. *Contributions to the Comparative Anatomy of the* CYCADACEÆ.

By W. C. WORSDELL, *F.L.S.*

(Plates **15** & **16.**)

Read 15th November, 1900.

FURTHER material having recently come to my hands the investigation of which afforded results of an importance which could not be overlooked, and, moreover, fresh insight into the significance of the Cycadean structure as a whole having demonstrated to me the far-reaching importance, as I conceived it to be, of certain facts whose value when they were, a few years ago, cursorily observed was inadequately estimated, induce me to bring together the scattered data in order to show their important bearing upon the problem as to the structural affinities of the Cycadaceæ.

The present investigations include that of young plants of the rare Queensland Cycad *Bowenia*, which exhibit in their stem-structure an extrafascicular vascular system similar to that of *Cycas*, *Encephalartos*, and *Macrozamia*. Other features in this genus are the concentric vascular strands, of purely physiological significance, scattered throughout the swollen parenchymatous tissue of the stem of one specimen, and the concentric type of structure of the cotyledonary bundles. *Macrozamia Denisonii*, F. Muell., with its tap-root preserved, exhibits in the region of the primary node extrafascicular concentric strands which are the homologues and earliest beginnings of the later-formed extrafascicular vascular zones in the same position.

Sections through the primary node of *Cycas Seemanni*, Al. Br., show rudimentary remnants of an ancient Medullosean character in the form of inversely-orientated vascular strands scattered here and there on the inner or ventral side of the extrafascicular zones. In one section the first extrafascicular zone is represented entirely by *concentric* strands. In the male and female cones of *Encephalartos* the structure of the peduncle is essentially that of the primary node of the vegetative stem, exhibiting extrafascicular concentric, or partially concentric, strands with loosely-compacted segments. A very interesting ancestral Medullosean character is seen in the sporophyll-bearing axial region of the male cones of *Ceratozamia latifolia*, Miq., and *C. mexicana*, Brongn., in the form of concentric, or remnants of concentric, strands constituting a ring, or vestige of such, within the vascular cylinder. The vegetative stems of *Zamia* and *Dioon edule*, which were investigated, offer nothing in their structure worthy of remark.

BOWENIA SPECTABILIS, Hook.

Young Seedling.

The excellent description by Mr. H. H. W. Pearson * of the structure of seedlings of this plant of 7 months' growth is so exhaustive, that it removes the necessity for me to do more than merely to supplement that treatise by one or two short additional remarks. The seedlings I examined (at a date prior to the appearance of Mr. Pearson's paper) were slightly younger than those of that author.

---

* Pearson: "Anatomy of the Seedling of *Bowenia spectabilis*, Hook. f.," Annals of Botany, vol. xii. 1898.

The bundles in the lower part of the cotyledon, which is still enclosed within the seed, exhibit a very decided tendency towards a *concentric* structure, as does also one of those in each cotyledon in the uppermost portion of the latter. The bundles are curved in contour so as to be quite three-fourths concentric. Fig. 1 (Pl. 15) represents such a bundle which exhibits a central protoxylem; the tracheides $x^{2(1)}$ I regard as having been cut off by a cambium whose cells are too indistinct to be drawn accurately, but which appear to extend entirely round the bundle, as I have endeavoured to indicate in the drawing. Although the bundles in the cotyledons of all Cycads are more or less curved or horseshoe-shaped in contour, those of *Bowenia* and *Stangeria* exhibit a much greater tendency towards the *concentric* structure than is the case with the rest. As the cotyledon is one of the three sets of primitive foliar organs in which ancestral characters are to be first of all sought for, it is a matter of great phylogenetic interest to discover in the cotyledons of the above-mentioned two genera this *concentric* type of structure in the bundles, which I regard as distinctly a primitive ancestral character. The course of the two cotyledonary bundles through the cortex of the stem to join the central cylinder is also a point worthy of mention. As I have already stated for the same bundles of the cotyledons and first scale-leaves of *Cycas* *, their course is *direct*, and does not assume a girdle-like direction, which is apparently a recently acquired character. The direct radial course of the bundles is the ancestral one, and is exhibited not only in connection with these most primitive of vegetative foliar organs in the seedlings of modern Cycads, but as a *normal* character throughout the vegetative axis of the Wealden Cycad *Bennettites*, as also in the more ancient Medulloseæ and Lyginodendreæ.

Older Seedlings.

Two-year-old plants of a varietal form (var. *serrulata*) grown by Messrs. Sander of St. Albans, and obtained from them by the authorities of the Royal Gardens, Kew, were carefully investigated.

In the extremely short young *stem* the central cylinder contains about three stout bundles, consisting of a great deal of secondary tissue and a large amount of parenchyma. Leaf-trace bundles occur in the cortex. Lower down, just *beyond* the transitional region between stem and root, or primary node, and where root-structure already prevails, the central stele is of considerable width, and the constituent bundles farther apart, owing to the expansion of the parenchymatous tissues. The large bundles composing the secondary tissues of the stele are now in places connected by delicate, few-layered bands of secondary vascular tissue, whose course is rather difficult to follow.

Outside the central stele are seen, in transverse section, other strands, which, there can be no doubt, represent the extrafascicular vascular tissue of *Cycas*, *Encephalartos*, and *Macrozamia*. Like the similar cases in these three plants, the extrafascicular tissues occur only outside a small part of the circumference of the central stele. Moreover, and this is the most important point of all, these outer vascular tissues have their parts diversely orientated—that is to say, that a portion of the strand, viz. the innermost portion, is *inversely orientated*, with phloem directed inwards and xylem outwards. This same phenomenon has been shown to occur in the region of the primary node of the three genera mentioned above. But, in these latter, it was seen that the strands concerned assumed the form of more or less perfect concentric structures, having a continuous or almost continuous elliptical contour; they are thus comparable to the concentric strands of *Medullosa Solmsii*, Schenk, var. *typica*, represented on pl. 3. figs. 1–4 of Weber & Sterzel's paper *. In the plant under consideration, however, the compound strand, consisting of the normally-orientated, with its opposed inversely-orientated, portion, is observed in the form, not of a concentric structure, but of a *flattened plate*, and is thus exactly comparable and homologous with the single flattened "Schlangenring" of *Medullosa porosa*, Cotta. I have observed a structure similar to this at one place in the circumference of the first extrafascicular ring of a seedling of *Cycas revoluta*, Thunb.†, where the inner inverted portion of the strand was, however, quite indistinct and its tissues but weakly developed as compared with the opposed normally-orientated portion. In *Bowenia*, on the contrary, at the young stage of development to which the extrafascicular ring has attained, the inner inverted portion is much more advanced than the outer (Pl. 15. fig. 2). As the plant grows older the latter will, doubtless, supersede and develop greatly in advance of the former, which will eventually, as in the older stems of the three genera above mentioned, become obliterated and be no longer recognizable.

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* "The Comparative Anatomy of certain Genera of the Cycadaceæ," Journ. Linn. Soc., Bot. vol. xxxiii. 1898, pp. 437–457.

Thus we see the young plant, in the preliminary stages of its development during the period when secondary thickening arises in the axis, exhibiting ancient ancestral phases of character which yield us a clue to its descent. Such ancestral rudimentary structures, conspicuous and pronounced in the young organism, but becoming obscured or completely vanishing in the adult, biologists have long been familiar with both in the animal and vegetable kingdoms.

The first-formed tracheides of the extrafascicular strand (fig. 2, x^2) are homologous with the same, short, isodiametric, reticulately-thickened tracheides occurring scattered promiscuously in the centre of all the secondary concentric strands in *Cycas* and the other genera.

The extrafascicular tissues were observed not merely in a single plant belonging to the batch emanating from St. Albans, but also in an individual kindly sent to me by Mr. W. G. Groves, of Holehird, Windermere, which belongs to the type form with acinaciform leaves, and which exhibits the tissues in question extending for a greater distance round the circumference of the central stele than is the case in the other plant.

In *Bowenia* we see, therefore, a *fourth* genus of Cycadaceæ exhibiting the phenomenon of extrafascicular vascular tissues in the axis.

---

* Beiträge zur Kenntniss der Medulloseæ, 1896.

† Journ. Linn. Soc., Bot. vol. xxxiii. 1898, p. 441.

In a plant of about the same age as the preceding, but possessing a much more swollen stem, which was also forwarded to me by Mr. Groves, no incipient stages of the normal extrafascicular tissues were anywhere observed. But a phenomenon of no morphological, although of considerable physiological, interest is present in the form of great numbers of concentric strands of very weakly-developed vascular tissue scattered throughout the cortex. They were of very varying sizes and shapes, some being quite small and circular, others large and tangentially extended in the form of more or less regular ellipses. In most cases the phloem of the strand is *internal* to the xylem, and the whole encloses a pith which is always more or less depleted of its starch, exhibiting thus a striking contrast to the ground-tissue of the stem between the strands which is replete with that substance: it is this peculiarity which enables the position of these strands to be everywhere recognized, even with the naked eye, on a transversely-cut surface of the stem.

This peculiar anomalous thickening has been described by Weiss * in the stem or root, as the case may be, of a great number of plants; as also by Schmitz †, L. Koch ‡, and Vöchting §. A satisfactory explanation of the phenomenon is afforded by the first-named author, who says: "In all those plants which grow very rapidly in thickness, and form an unusually large amount of reserve foodstuffs, *a rapid path of transportation* is necessary. As the parenchyma transports the substances by means of diffusion and the phloem by open pores, the *secondary medullary and xylem-, phloem-, or fibro-vascular strands* are of high importance for these plants." In *Bowenia*, as described above, these secondary strands occur in the *cortex.*

Macrozamia Denisonii, F. Muell.

A plant having a stem-diameter of about one inch, obtained a few years ago from Mr. William Bull, of Chelsea, exhibits the following structure.

At the base of the insertion of the leaves on the stem is a wide central cylinder fairly regular in contour except in those places where a leaf-trace bundle joins it. The cylinder varies much in the development of its different parts; on one side its segments are extremely small and reduced to tiny bundles isolated from each other by broad medullary rays. The protoxylem is quite deranged and obliterated, and small transfusion-like tracheides are seen scattered in the parenchyma to the inside of the wood.

In the cortex and pith mucilage-canals are fairly numerous, but do not appear to form such a network as in *M. Fraseri*, Miq.; they mostly assume a vertical course.

Medullary bundles are entirely absent. This is extremely important, as exhibiting a marked contrast in this respect to *M. Fraseri*, Miq.

The leaf-trace bundles during their tangential course have the same development of spirally- and reticulately-thickened tracheides as in *M. Fraseri*, Miq. Where they unite with the central cylinder they are of very different sizes, some being very small, others very large. The latter result from the fusion of two or three in the cortex before they reach the cylinder. In some bundles all the secondary tracheides have *scalariform* pits, these latter passing gradually over into the reticulations of the protoxylem. In some bundles the latest-formed secondary tracheides have bordered pits, and there is a gradual transition between these and the scalariform tracheides further to the inside. The scalariform pittings prevail in the bundles of the leaf-base, while those on the upper part of the petiole have bordered pits on their tracheides.

---

* J. E. Weiss: "Anatomie und Physiologie fleischig verdickter Wurzeln," Flora, 1880.

† Schmitz: Sitzungsber. der naturforsch. Gesellsch. zu Halle, 1874.

‡ L. Koch: Untersuchungen über die Entwickelungsgeschichte der Crassulaceen. Heidelberg, 1879.

§ H. Vöchting: Hanstein's Botanische Abhandlungen, iii. 1875, Heft 1.

Lower down, near the transitional region between stem and root, or the primary node, the central cylinder develops a much thicker ring of vascular tissue, with a correspondingly smaller pith. The inner elements of the wood, including the protoxylem, become disjointed and scattered about the pith.

Immediately outside the central cylinder three or four large, *fan-shaped* strands are seen. The first-formed innermost tracheides are reticulated and parenchymatous in shape, lying without any regular arrangement on the ventral side of the later-formed typically-shaped tracheides. These strands, if followed upwards, are seen to gradually bend inwards and eventually to fuse with the central cylinder; one such which was followed was seen to separate off, just before it fused, a small concentric bundle which passed again to the outside of the ring. The strands taper considerably as they pass upwards and inwards.

Still lower down the cortical strands increase somewhat in size, the largest assuming a semi-cylindrical shape and enclosing a half-pith in which are scattered, loosely and irregularly, the same short, reticulate tracheides, the first-formed woody elements of these strands. The secondary wood and phloem of the latter is massive. There are also smaller, less regularly-shaped strands, which are elongated tangentially and contorted, or round, oval, and fairly regular in outline. The latter, the smallest, often lie immediately on the *outer* edge of the others in a somewhat oblique position. The xylem of these smaller strands consists for the most part of the short, reticulate elements with, often, but very few of the typical secondary tracheides. The larger strands may be either completely *concentric* in structure, which is rather the rarer case (Pl. 15. fig. 3), or they may be greatly curved while retaining still the collateral character; or, again, they may exhibit, on their inner side, traces of a cambium with two or three secondary elements cut off, here and there.

The strands may, however, instead of exhibiting a semi-cylindrical form, be completely flattened out.

Lower down in the axis they completely die away.

These cortical cauline strands are homologous in nature with the concentric strands constituting the outermost, and occasionally (see *infra*) one of the intermediate, rings of the stem of *Cycas*, as also with the concentric strands immediately outside the root-stele in the primary node of the seedling of *Cycas*. They are, indeed, the very same strands which I have met with and described in the same region of the axis of *Encephalartos horridus*, Lehm.*, and which I stated, in the paper below quoted, to be homologous with the extrafascicular rings which occur in four genera of modern Cycads. That is to say, it is in this form of isolated, concentric, or partially concentric strands that the extrafascicular rings, or at least the first of these, make their earliest start in development in the primary node; the collateral structure at a later stage, during the subsequent development and growth of the plant, assuming complete sway.

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* "The Comparative Anatomy of certain Species of *Encephalartos*," Trans. Linn. Soc. ser. II. Bot. vol. v. pt. 14, 1900.

In the above-mentioned paper on *Encephalartos* I stated that these outer concentric strands are homologous with the so-called "anomalous strands" described by Scott* in *Medullosa anglica*; they are also, in like manner, homologous with the extrafascicular strands figured and described by Weber & Sterzel† in certain species of *Medullosa*. And my fig. 3 (Pl. **15**) may be aptly compared with the strand marked *b* in fig. 2, pl. 4, of the last-named paper, which represents a fragment of the stem of *Medullosa Leuckarti*, Göpp. & Stenz., and which I have reproduced in my fig. 4.

The upper region of the *root* exhibits a *triarch* structure. At a lower level, where its diameter is smaller, it becomes *tetrarch*; still lower again *triarch*, and finally *diarch*. In this narrowest portion of the root an internal periderm occurs.

CYCAS SEEMANNI, Al. Br.

Through the kindness of Prof. F. W. Oliver I was enabled to examine a slide at University College containing, amongst others, a transverse section through the primary node, in the region exhibiting root-structure, of this plant. The structure there shown confirms in a remarkable manner the conclusion I have from time to time drawn and put forward as a result of an examination of sections from the same region of the vegetative axis in *Macrozamia Fraseri*, Miq., *M. Denisonii*, F. Muell., *Encephalartos horridus*, Lehm., and *Cycas revoluta*, Thunb.

In my paper on *Macrozamia Fraseri*, Miq., I ventured to draw the inference, from the observation of small inverted strands (*i. e.* strands whose xylem and phloem are inversely orientated as compared with the normal condition) occurring here and there, quite infrequently on the ventral side of some of the extrafascicular collaterally-constructed rings, that the latter derive their origin, through descent with modification, from the *concentrically-constructed* rings of vascular tissue of the fossil Medulloseæ.

In the plant under consideration these inverted strands once more make their appearance, but this time in greater abundance, and with a distinctness which leaves no doubt as to their position and orientation. After considering the structure which is here incontrovertibly presented to us, there can no longer remain, in my own mind, a shadow of doubt that *the four genera of modern Cycads which exhibit the character of extrafascicular rings of vascular tissue are directly descended from some group of plants amongst the Cycado-filices, like the Medulloseæ, which possess similar extrafascicular rings in their stems, but (well-nigh universally) of a* concentric *structure.*

Of extreme interest, however, and strongly confirming my conclusions, is the case of *Medullosa stellata* var. *gigantea*, which already, at that remote epoch, had advanced

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* "On *Medullosa anglica*, a new representative of the Cycado-filices," Phil. Trans. Roy. Soc., B. vol. **191**, 1899, pp. 81–126.

† Beiträge zur Kenntniss der Medulloseæ, 1896.

very far indeed in the modern Cycadean direction, by adopting a *collateral* structure in its extrafascicular strands *. My fig. 5 (Pl. 16), a diagrammatic representation of the structure in *Cycas Seemanni*, Al. Br., shows portions of three rings of vascular tissue outside the central stele. One of the segments of the innermost ring is almost *concentric* in structure, the inner inversely-orientated portion being in intimate connection with the outer. Attached to the second ring, on its inner or ventral side, are seen about six (and there are in reality smaller ones present, which are not drawn in the figure) *tiny inverted strands*; these represent the last sporadic remnants of *the inverted portion of the well-developed ring immediately outside them*. As the cambial activity has become (for obvious economical purposes) at length almost exclusively confined to this latter part of the ring, the inner inverted portion is naturally tending to entirely disappear (as it already has done throughout the greater part of the axis), leaving these mere rudiments to testify to its former normal presence in the ancestors of the plant.

In the third ring a well-developed *inverted strand* occurs attached to an isolated normal segment of the ring.

Fig. 6 (Pl. 15) represents a segment of the vascular tissue of the *stem* in which the first extrafascicular ring (r^2) consists of widely-separated *concentric* strands, exhibiting the same structure as, and perfectly homologous with, the concentric strands forming the outermost ring of the stem in most species of *Cycas*.

In the present case the ring of concentric strands is intercalated between the central cylinder and a normal collaterally-constructed extrafascicular ring, the first instance of the kind I have ever seen.

The structure described by Gregg † in the root of this same plant is merely a variant, though a somewhat freakish one, on that above detailed by myself. Neither his structure nor mine is to be regarded as, *in essentials*, an abnormality, much less a freak or sport: both are but vestiges of the former *normal* structure of the ancestors of the plant. The strand in Gregg's fig. 1, formed by the cambium $a.cb^1$, is simply the inverted ventral portion of the part, opposed to this latter, of the first extrafascicular ring formed by the cambium $a.cb^2$; these two are homologous with the inverted strand is^1 of my fig. 5 together with its opposed outer strand. The variation appearing in Gregg's structure consists in the curious backward folding of the cambial tissue *ncb* on either side of the central stele so as to become continuous with that of the cambium $a.cb^1$ of the inverted strand of each side, instead of, as is the normal case of my figure, curving round and enclosing the protoxylem at each end of the stele. This mode of development gives rise to the false appearance of two distinct concentric strands possessing a central phloem and an external xylem (see Gregg's fig. 3). But no importance whatever is to be attached to this phenomenon. If the cambium $a.cb^1$ had become continuous with the cambium $a.cb^2$ of the first normal extrafascicular ring, instead of with the cambium of the central stele, the structure would have been attained such as Gregg found in another root and represented in his fig. 4, that, viz., of two concentric steles of normal structure outside the central stele. This involves the breaking up of the first collateral extrafascicular ring into a number of concentric strands. This latter condition I hold, as elsewhere stated, to represent the most primitive type, from which the collateral ring has been derived. Therefore Gregg's fig. 4 shows us the most primitive type of structure, his figs. 1 and 3 an advance thereon in the direction of the ordinary collateral rings of the Cycadean stem.

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* Weber & Sterzel, *loc. cit.* pl. viii. fig. 1.

† "Anomalous Thickening in the Roots of *Cycas Seemanni*," Ann. Bot. vol. i. 1887.

Hitherto the phenomenal structure discovered by Gregg has remained inexplicable; in the light of further researches it is now seen to possess important bearings on the phylogenetic relationships of the plant concerned; and I may remark that the mere observation of structures is comparatively useless unless at the same time their meaning and significance are ascertained. I hope I have succeeded in so doing.

ENCEPHALARTOS LANUGINOSUS, Lehm.

Male Cone.

The structure of the *peduncle* is of great interest, exhibiting, in rather more primitive form, the same structure as is found in the vegetative axis. This is what one would naturally, *à priori*, expect, seeing that the cone is the most primitive axial organ of the plant.

Besides the central cylinder are numerous extrafascicular strands of varying sizes and shapes, some of which are very much elongated tangentially, consisting of many segments and perfectly straight, while others are more or less curved in contour (Pl. **16**. fig. 8). Some of the strands are built up of two or three bundles or segments, arranged *concentrically*, with their xylems *turned* towards each other so as to form a loosely-compacted *concentric* strand (Pl. **15**. figs. 7 & 9). Here and there may be seen two strands, of which one is normally and the other, opposed thereto and nearer the cylinder, inversely orientated. In one place a tiny *concentric* strand, constituted of three distinct parts, lies between the central cylinder and a large collateral normally-orientated strand. At many points the strands of the central cylinder bend outward, just as do those in the stem of *Medullosa* * when connecting with the strands of the first extrafascicular ring, or giving off leaf-traces, and as is also seen in the lower part of the peduncle of *Stangeria*.

The extrafascicular strands are larger and more frequent above the base of the organ, in the lower part fewer and smaller. A curious deep invagination has been formed by the cylinder in one place (Pl. **15**. fig. 9).

A very few minute foliar traces occur in the outer part of the cortex, either singly or in pairs.

All the extrafascicular strands of the peduncle I regard as homologous with the concentrically-built strands occurring outside the central cylinder in the region of the primary node of the vegetative axis of *Cycas*, *Encephalartos*, and *Macrozamia*, as also with the extrafascicular collaterally-built zones of these three latter genera and of *Bowenia*.

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* Weber & Sterzel, Beiträge zur Kenntniss der Medulloseæ, pl. 4. fig. 2, pl. 5. fig. 2. Scott: "The Anatomical Structure presented by the Peduncles of Cycadaceæ." Ann. Bot. vol. xi. 1897, pp. 398–419, figs. 1 & 2.

The bundles of the central cylinder show no indication of the presence of centripetal xylem.

The bundles composing the cylinder of that part of the cone to which the sporophylls are attached are orientated with extreme irregularity. Outside the cylinder are bundles, also very variously orientated, some lying sideways, others completely inverted, others again having a partially concentric structure; it is to those lying sideways that the bundles from the sporophylls unite.

In the basal region of the sporophyll are several bundles in a row and one or two above and below this row. Those in the row eventually resolve themselves into two which join on to the bundles of the axis (usually two lying sideways). The lowermost bundle appears to fuse with one of these two axial bundles, the small upper bundle to unite with the cylinder of the axis independently.

The material being in such a withered condition, it was rather difficult to follow the course of the bundles satisfactorily.

A *female* cone of *E. Hildebrandtii* was also examined, with the result that the structure was found to be essentially the same as that of the male cone above described. Small, perfectly *concentric* bundles were observed in the sporophylls.

CERATOZAMIA LATIFOLIA, Miq., and C. MEXICANA, Brongn.

Male Cone.

The cone of *Ceratozamia* seems, so far as my observations extend, to be unique, in the exhibition of an ancient Medullosean character which I can find nowhere else in the group of modern Cycads. This peculiarity consists in the possession of an *intra-fascicular* ring of strands, *i. e.*, a zone *internal* to the central cylinder which, in development, is inferior to the latter. Such an internal ring may, in the Medulloseæ, either possess a distinct individuality of its own, as is shown in pl. 7. figs. 1 & 2 and pl. 8. fig. 3 of Weber & Sterzel's paper, or the bundles composing it may merely be the outermost members of a system of strands permeating the pith in all parts, as in pl. 2. figs. 1 & 2 of the same paper. In view of this transition existing between the medullary system of scattered bundles and the ring of strands immediately internal to the cylinder of the stem; in view, moreover, of the further fact that this internal ring may in certain species of *Medullosa* assume a proportion, as regards the development of its strands, scarcely inferior to that of the main cylinder itself, we may, I think, formulate the following conclusions—That all the vascular strands *internal* to the central cylinder of the stem in the Medulloseæ are homologous one with another and belong to the same vascular system, and this in spite of the great variation in size and arrangement of these strands in the different species; further, that *all* these medullary strands are homologous with, and belong to the selfsame vascular system as, the central cylinder itself, for a continuous series of transitional forms exists in the genus between the central cylinder and the minutest of the scattered medullary strands. The structure is, probably, analogous to that which obtains in the stems of certain Ferns, such as *Dicksonia*, where in the centre of the stem, internal to the large, elongated steles forming a kind of central cylinder, are scattered innumerable tiny steles united together into an anastomosing network; these minute steles have, almost certainly, arisen in the past by the breaking up of a few large steles. In modern Cycads the anastomosing system of medullary bundles characteristic of *Encephalartos* and certain species of *Macrozamia* has had, in all probability, in the far past, a similar origin to the internal central bundles of *Medullosa* and the fern *Dicksonia*. On this view of the direct homology existing between the central cylinder and the medullary strands, we can understand why the latter should be present in some species of *Macrozamia* and absent in others, for this would be merely equivalent to the presence of, say, two extrafascicular vascular zones in one species, and the presence of only one such zone in another species; the presence or absence in these plants of medullary strands is, in short, a character dependent on a variable amount of development of the normal vascular strands. If the medullary bundles, like the leaf-traces, constituted a system of their own distinct from that of the vascular cylinders, it would be strange and inexplicable that this system should be present in one species of *Macrozamia* and absent in another, as I have found to be the case.

In the light of the above view, however, the origin and homologies of the medullary-bundle-system in modern Cycads and the Medulloseæ are made plain: they are the broken-up fragments of a ring or irregular group of steles forming the innermost or central portion of the vascular system of the stem.

My fig. 10 (Pl. 16) of a portion of the cylinder of the sporophyll-bearing region of the cone-axis of a male plant of *Ceratozamia mexicana*, Brongn., and fig. 11 of the entire cylinder in *C. latifolia*, Miq., represent the structure pertaining to the first of the above-named types, there being no other bundles in the pith except those constituting the intrafascicular ring.

The bundles composing the intrafascicular rings in fig. 1 & 2 of pl. 7 and fig. 2 of pl. 2 of Weber & Sterzel's paper are seen to be more or less incomplete in structure, a portion of the otherwise concentric bundle being lost either from the inner (as in the first two figures above cited) or from the outer side (as in the last-cited figure).

Now my fig. 11 shows strands belonging to this intrafascicular ring in which the reduction has gone still further, so that as a rule, only a very small segment of what was once (in the plant's ancestors) a perfect *concentric* strand (such as is seen in pl. 2. fig. 1 of the above-mentioned paper) has been left remaining, and, from the present orientation of this bundle, it can be clearly determined to which region of the original concentric strand it belonged, The least reduced condition of the latter is represented by a case in my fig. 11, where three bundles (two smaller and one large one) are closely approximated and with their xylems mutually directed towards each other. In fig. 10 it is (in three out of four cases) the outermost portion of the former concentric strand which is left remaining, one of which portions almost equals in size half of that of the original strand. But I have also found cases where the complete *concentric* structure has been preserved (fig. 12), such a strand being the exact counterpart and homologue of the complete concentric strands occurring in the same region of the stem in the Medulloseæ. By tracing these strands upwards or downwards, they are seen to be in connection here and there with the main outer cylinder. What clearly indicates their vestigial ancestral character is the fact that many of them end blindly and that, in many cases, their tissues are not so well-developed as those of the bundles of the outer ring, staining but faintly with safranin and hæmatoxylin: a sure indication that such strands are on the road to extinction.

The intrafascicular ring of strands is confined to the *male* cone in *C. latifolia*, Miq.; it has also been mentioned by Scott[*] as occurring in the male cone of *C. mexicana*, Brongn. In other species it appears to be absent, this fact being on a par with that of the absence of medullary bundles from the vegetative axis of *some* species of *Macrozamia* (see *supra*). Thibout[†] describes and figures these medullary bundles, and I have myself[‡] in a former paper brought them under notice. Their real significance and morphological value has, however, hitherto been completely overlooked.

Several species of the genus *Zamia* and also *Dioon edule*, Lindl., have been studied from the point of view of their anatomical structure; but as the latter conforms in every respect with that of Cycadean genera, previously described by me, which do not possess extrafascicular vascular tissue in their stems (*Stangeria*, *Ceratozamia*), but only a single cylinder, it is not considered worth while to give any details of the structure of these genera.

Microcycas, the very rare Cuban plant, is thus the only genus which remains uninvestigated; its structure will, however, probably conform to that of *Zamia*.

Summary.

The chief results of this investigation are as follows:—

1. The discovery in a fourth genus of Cycadaceæ, viz. *Bowenia*, of extrafascicular vascular tissue. This tissue, in the primary node, consists of both normally-orientated and inverted portions, such as is known to be characteristic of the strands occurring in the same region in *Encephalartos* and *Cycas*; but while in these latter genera the two portions of the strand are united together into a single, compact, concentric, or semi-concentric structure, in *Bowenia* they occur as distinct flattened strands.

2. The occurrence of *concentric* or sub-concentric bundles in the *cotyledon* of *Bowenia*, a phenomenon heretofore only known to occur in *Stangeria*.

3. A much-swollen stem of *Bowenia* exhibits *concentric* strands scattered in the cortex with inverted orientation of the parts of the vascular tissue composing them. These strands are correlated with the swollen parenchymatous character of the stem, and are merely physiological adaptations for the rapid conveyance of nutriment throughout the axis, and possess no morphological value.

4. The occurrence in the region of the primary node of *Macrozamia* of extrafascicular *concentric* strands such as those found in the same region of the axis in *Encephalartos*

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[*] Scott, Ann. Bot. vol. xi. 1897, p. 412.

[†] Thibout: Recherches sur l'Appareil mâle des Gymnospermes, p. 24 (1896).

[‡] Worsdell: "The Vascular Structure of the Sporophylls of the Cycadaceæ," Ann. Bot. vol. xii. 1898, p. 232.

and *Cycas*. These structures are the first beginnings and foundations of the later-formed extrafascicular rings.

5. In the male *peduncle* of *Encephalartos lanuginosus*, Lehm., occurs a replica of the structure, although in a more ancient and primitive form (in accordance with the more primitive character of the organ producing it), of the vegetative stem. This consists of extrafascicular strands, most of which, either by their curved contour or by the occurrence of inner inverted portions of their tissue, indicate a much nearer approximation to the ancestral Medullosean structure than the same rings occurring throughout the greater part of the vegetative axis.

6. A section of the *root* of *Cycas Seemanni*, Al. Br., passing through the region of the primary node exhibits, in three of the extrafascicular rings, very distinct and palpable vestiges (of which in *Macrozamia Fraseri*, Miq., only slight, and not altogether unequivocal, traces were found) of the *inner portions* of those rings having *inverted orientation* of their parts.

Another section of the *stem* exhibits the first extrafascicular ring in the form of a zone of sparsely-scattered circular *concentric* strands in place of the ordinary collaterally-constructed ring. These concentric strands normally occur, in all species of *Cycas*, as the *outermost* of the extrafascicular rings.

7. The genera *Zamia* and *Dioon* belong to the mono-cylindric type of *Ceratozamia* and *Stangeria*, in showing a complete absence of any extrafascicular rings in the vegetative axis.

In conclusion, I would add that the present paper, as also other treatises of mine on the same subject, have been written with two main objects in view, viz.:—(1) To contribute towards a clear and precise knowledge of the vegetative structure of the Cycadaceæ, which group of plants is, on quite other grounds, attracting considerable attention in the botanical world of today. (2) To point out, by means of that knowledge of the structure, the probable phylogenetic relationship and line of descent of these plants. This latter must ever be one of the most important and worthy objects of all botanical study, and it is remarkable that in these plants the anatomical structure *per se* should demonstrate that relationship to such a great extent.

I desire to express my thanks to the Director of the Royal Gardens, Kew, and in particular to the Assistant-Curator, Mr. W. Watson, and also to Mr. W. G. Groves, of Windermere, for their kindness in supplying me with a portion of the material for these investigations.

EXPLANATION OF PLATES 15 & 16.

The following are the abbreviations used in the lettering of the figures:—

x = xylem : x^2 = secondary centrifugal xylem ; x^1 = centripetal xylem ; $x^{2\,(1)}$ = centripetal xylem recently formed by a cambium ; px = protoxylem ; ph = phloem ; ph^2 = secondary centrifugal phloem ; ph^1 = centripetal phloem ; r^1, r^2, r^3 = first, second, and third vascular rings respectively ; is = inverted strand ; s = concentric cortical strand ; ss = small ditto ; cc = central cylinder ; ir = intrafascicular ring ; lt = leaf-traces.

Bowenia spectabilis, Hook.

Fig. 1. Transverse section of a sub-concentric bundle in the cotyledon.

2. Transverse section of a portion of the central cylinder of the root in the primary node, showing extrafascicular strands.

Macrozamia Denisonii, F. Muell.

Fig. 3. Transverse section of a concentric cortical strand just outside the central cylinder of the primary node.

Medullosa Leuckarti, Göpp. & Stenz.

Fig. 4. Transverse section of a concentric strand just outside the central cylinder of the stem. (Diagrammatic.)

Cycas Seemanni, Al. Br.

Fig. 5. Transverse section of a portion of three extravascular rings in the primary nodal region of the root. (Diagrammatic.)

6. Transverse section of a portion of three vascular rings in the primary nodal region of the stem. (Diagrammatic.)

Encephalartos lanuginosus, Lehm.

Figs 7, 8, & 9. Transverse sections of portions of two vascular rings in the male peduncle. × 8.

Ceratozamia mexicana, Brongn.

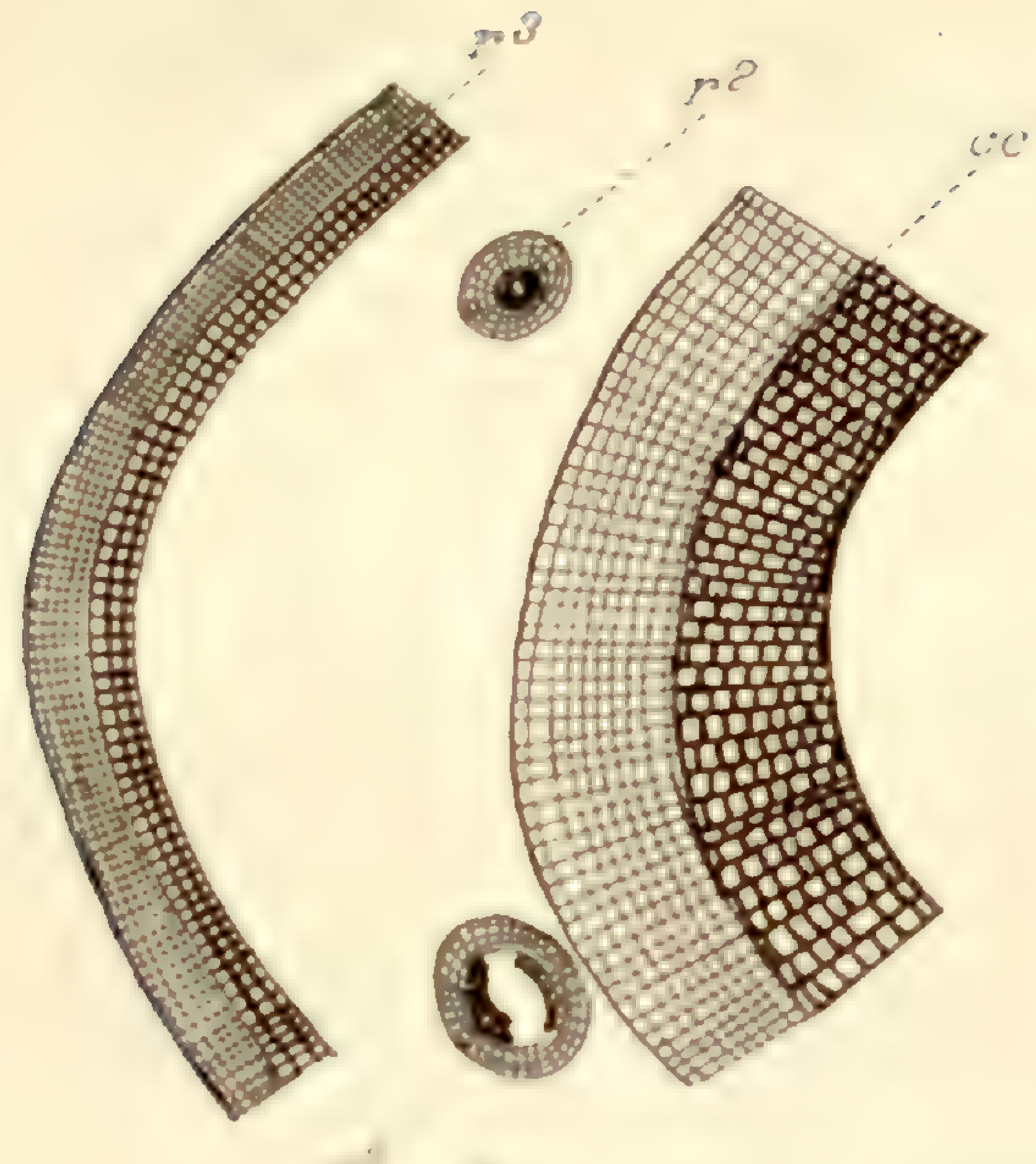
Fig. 10. Transverse section of a portion of the vascular cylinder of the axis of the male cone. × 8.

Ceratozamia latifolia, Miq.

Fig. 11. Transverse section of the vascular cylinder of the axis of the male cone. × 8.

Ceratozamia mexicana, Brongn.

Fig. 12. Transverse section of a concentric medullary bundle in the axis of the male cone. × 60.



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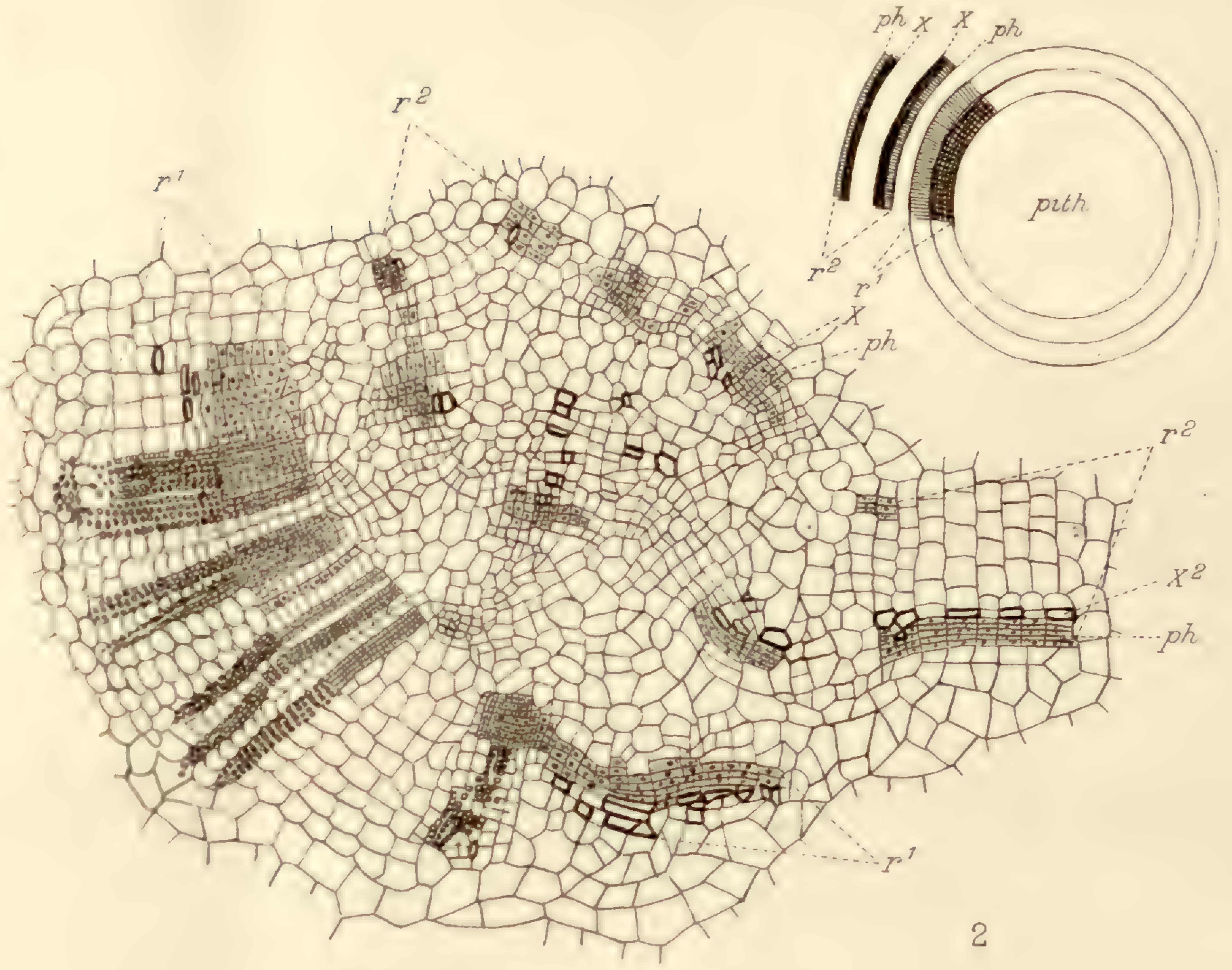
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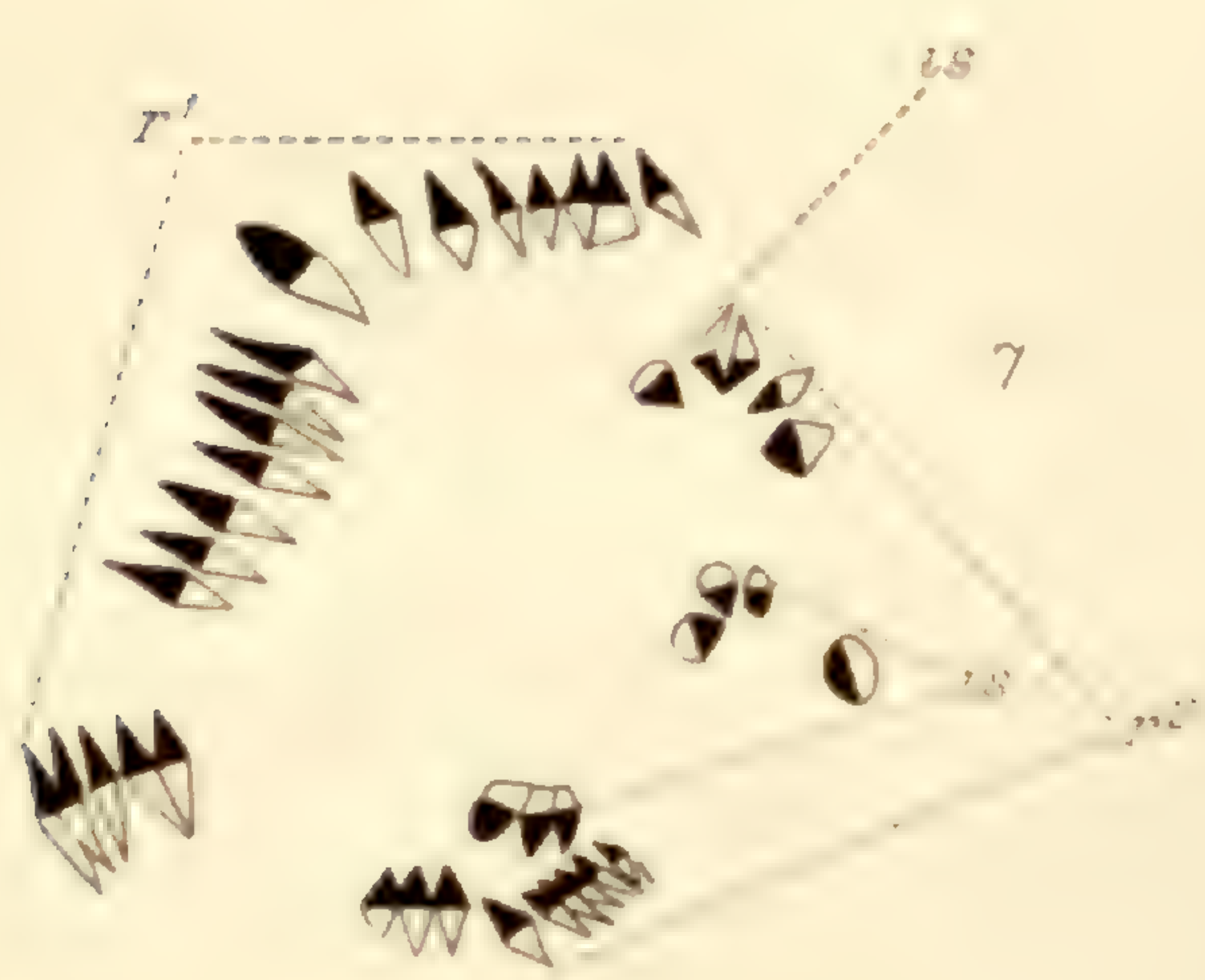

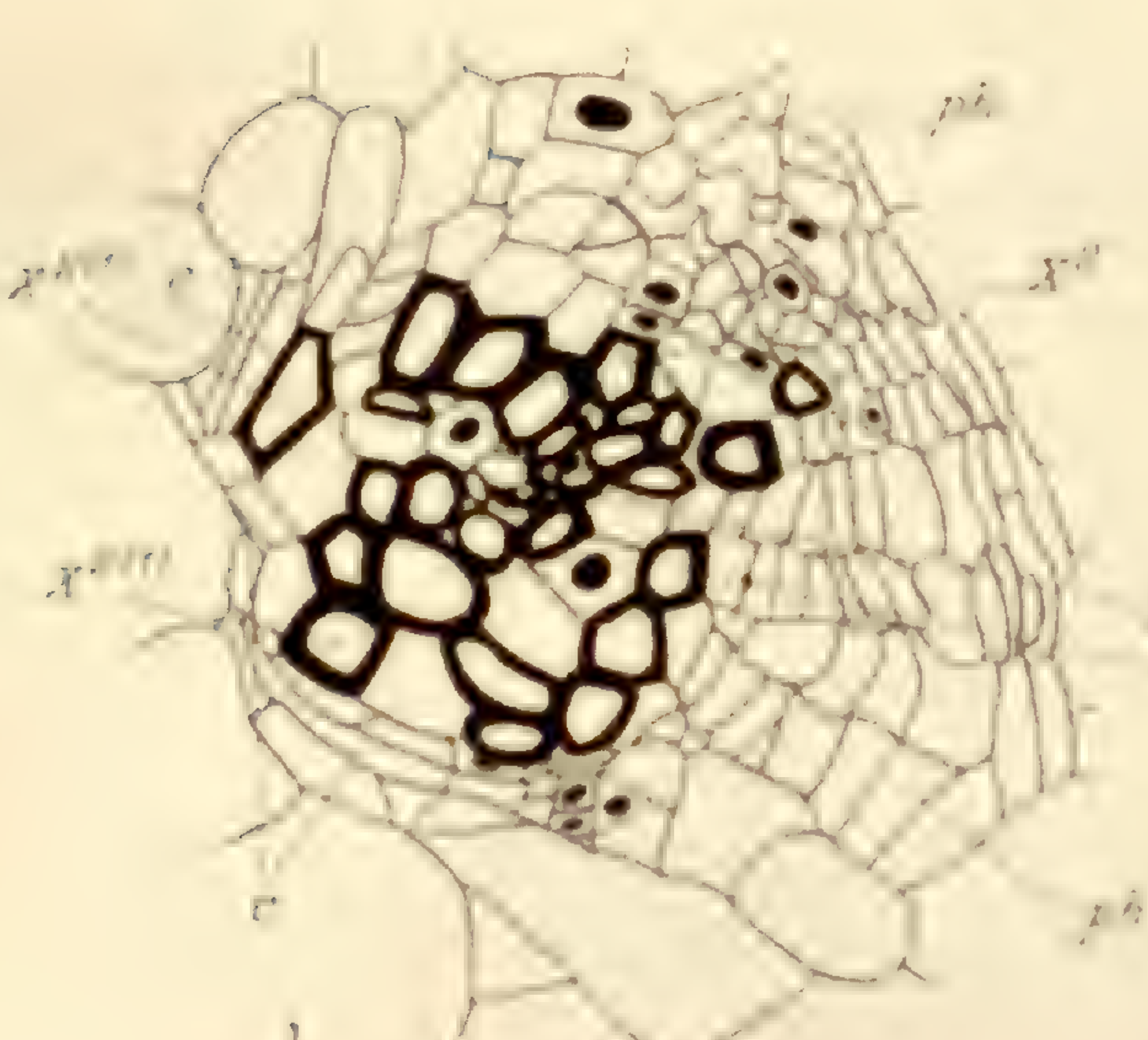
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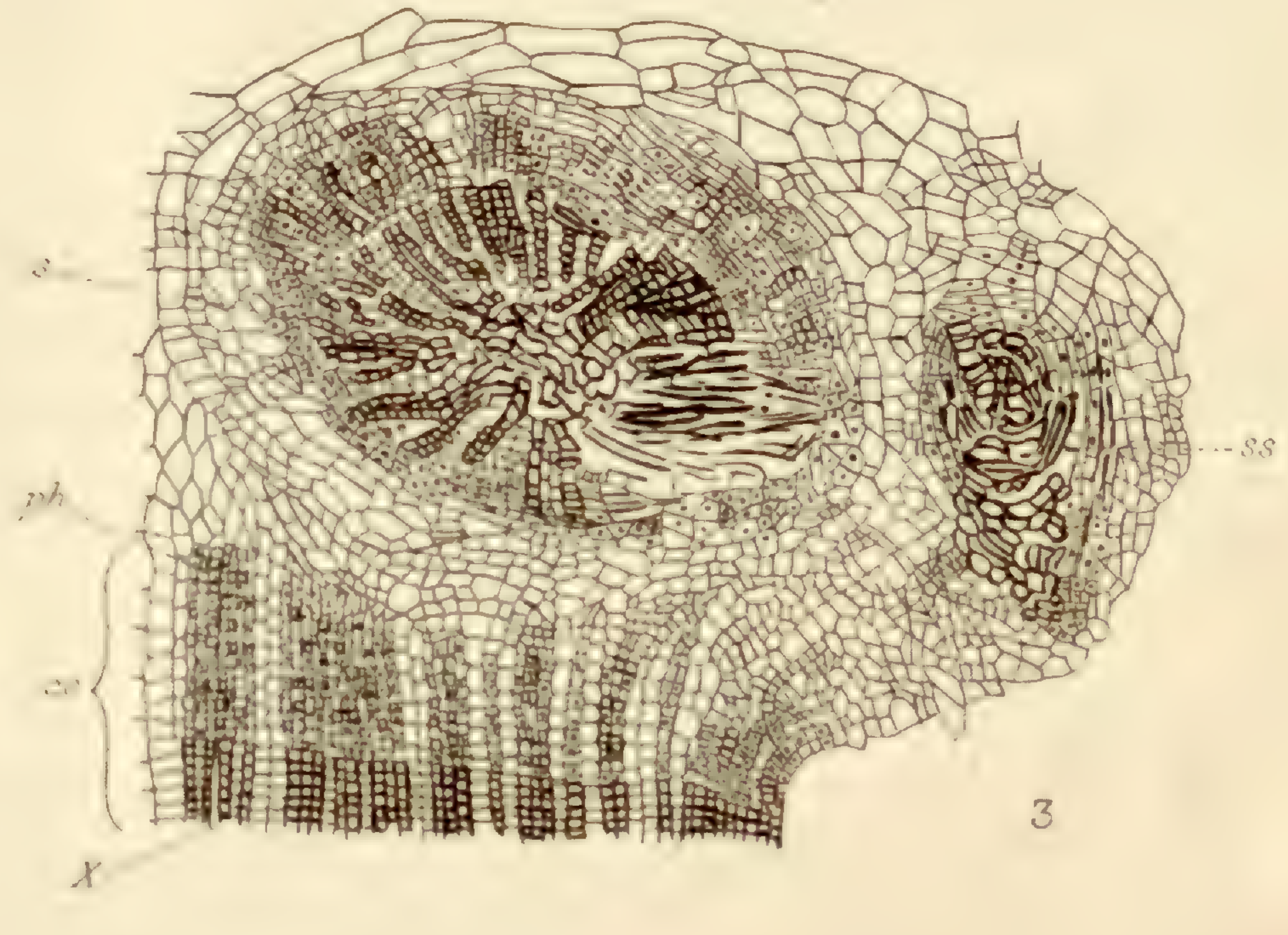

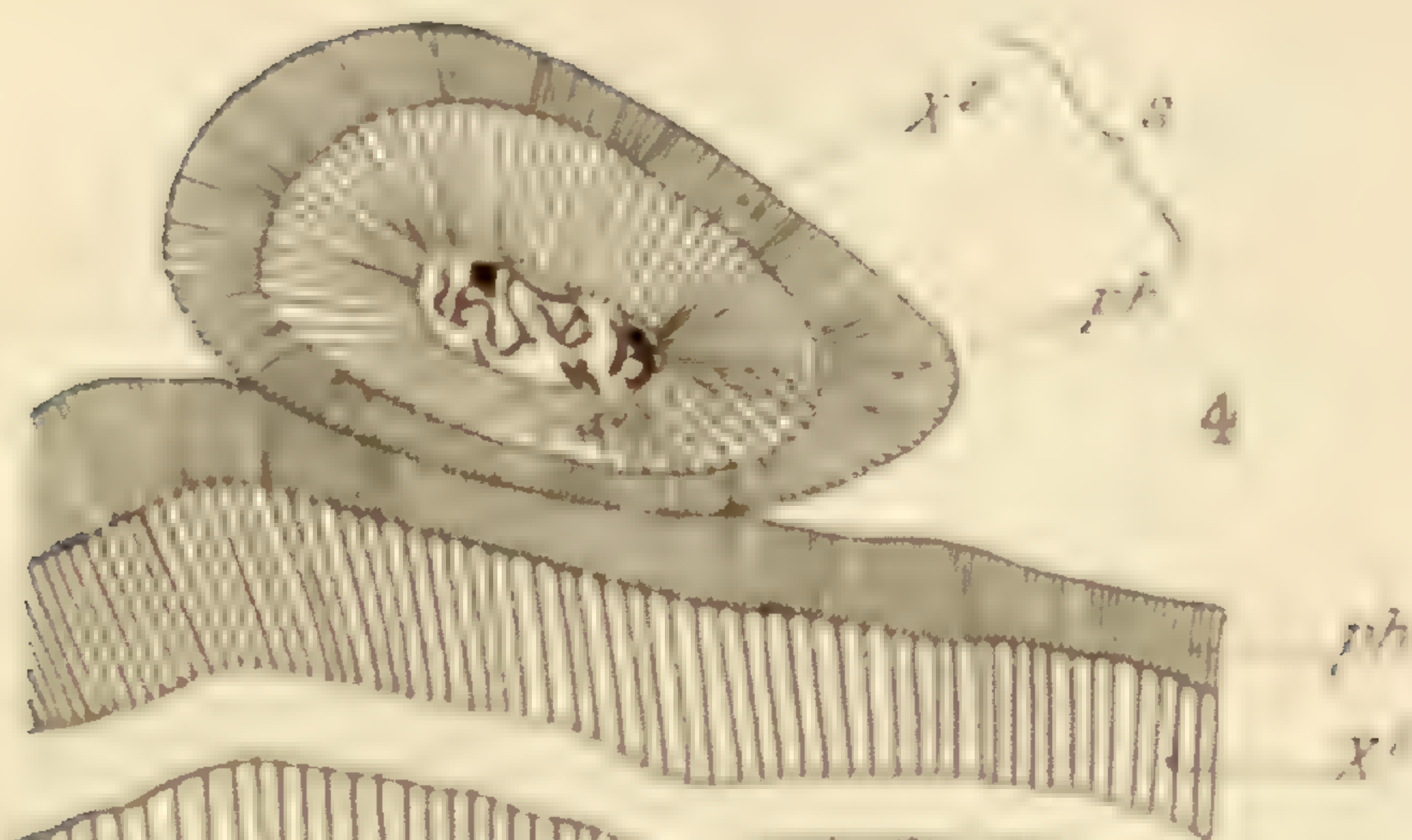
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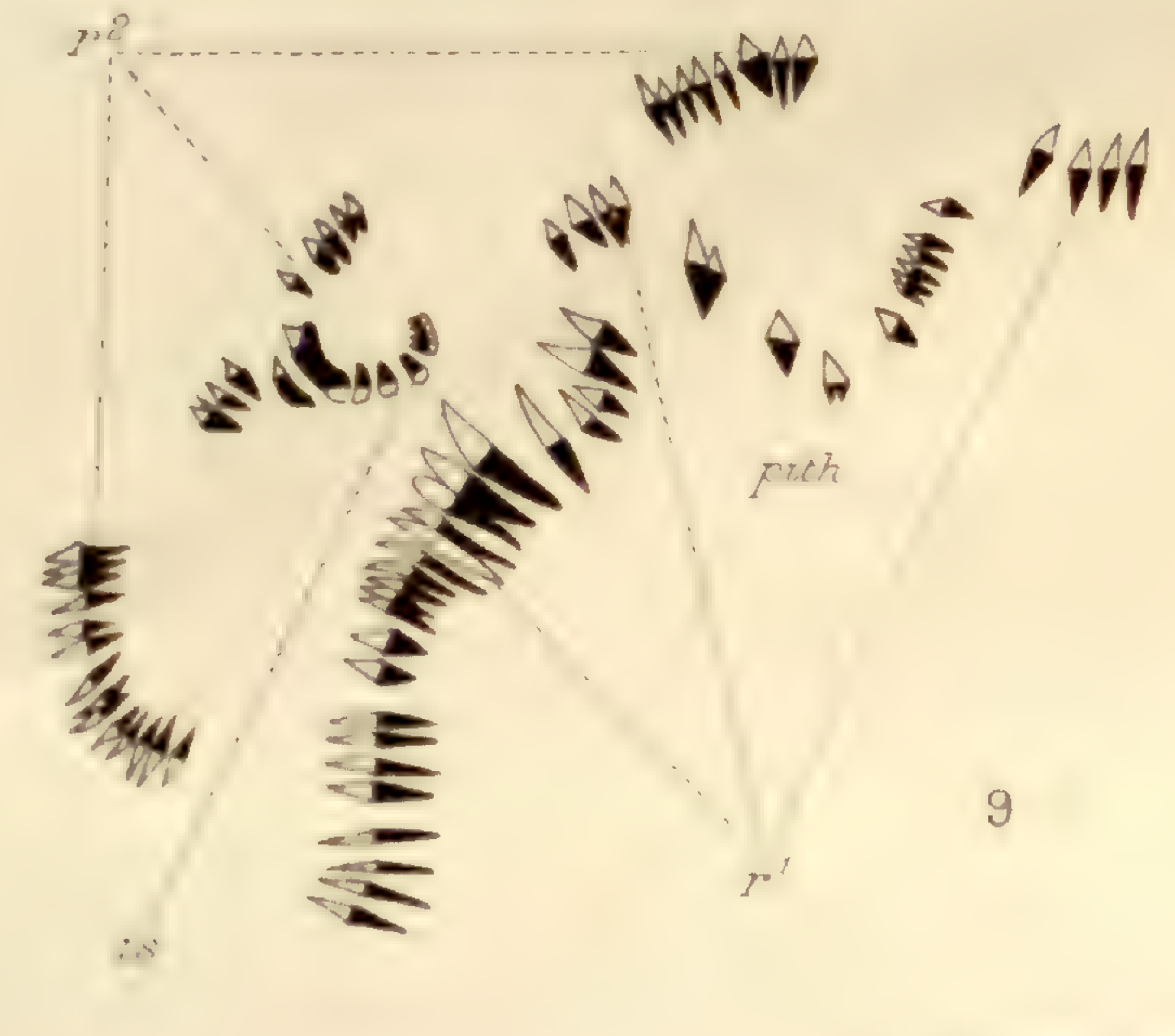
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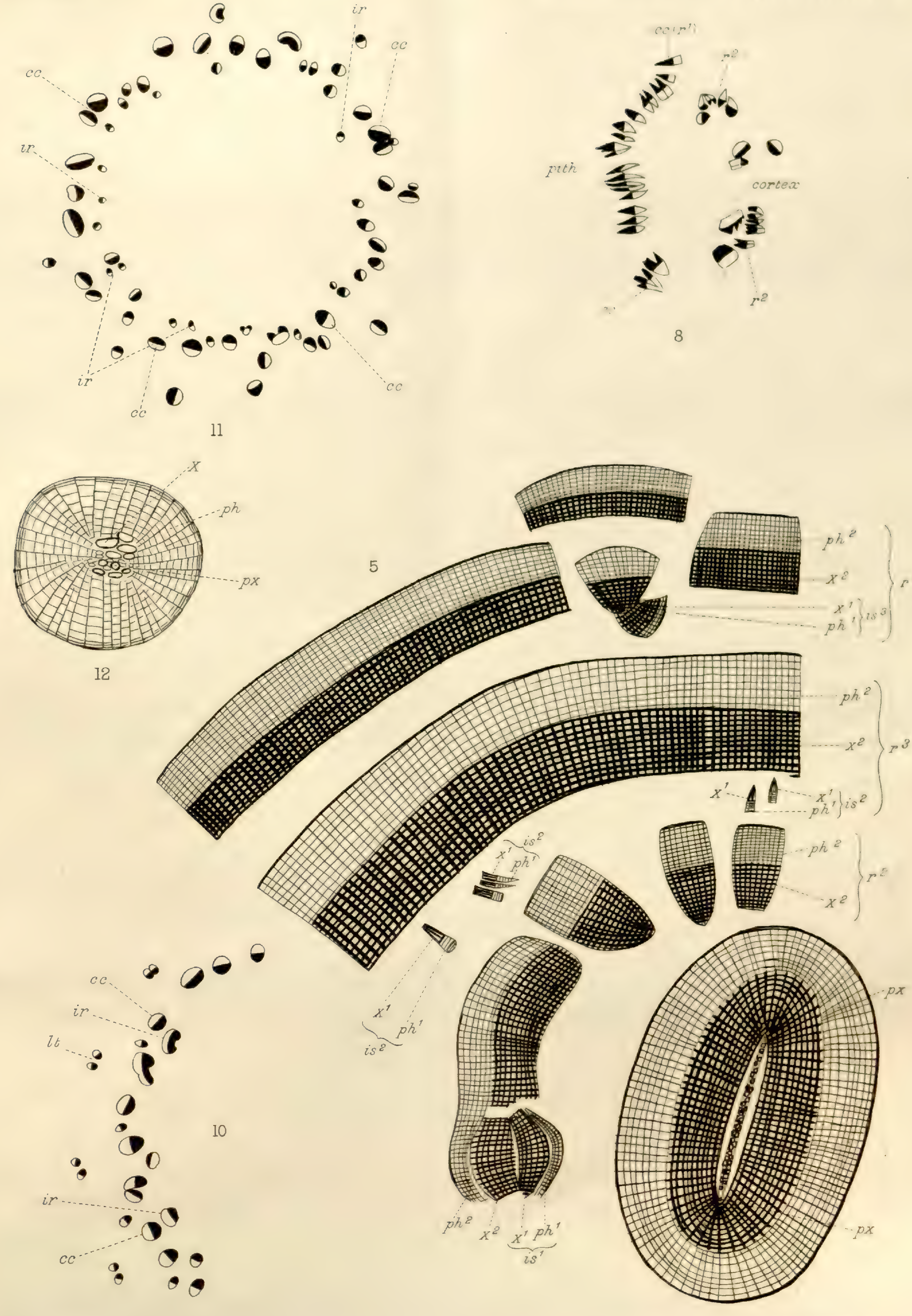
COMPARATIVE ANATOMY OF THE CYCADACEÆ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2nd Ser. BOTANY.] [VOL. VI. PART 3.

THE

TRANSACTIONS

OF

THE LINNEAN SOCIETY OF LONDON.

A CONTRIBUTION TO THE FRESHWATER ALGÆ OF CEYLON.

BY
WILLIAM WEST, F.L.S.,
AND
GEORGE STEPHEN WEST, B.A., F.L.S.,
HUTCHINSON STUDENT OF ST. JOHN'S COLLEGE, CAMBRIDGE;
PROFESSOR OF NATURAL HISTORY, ROYAL AGRICULTURAL COLLEGE, CIRENCESTER.

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March 1902.

III. *A Contribution to the Freshwater Algæ of Ceylon.*

By W. West, *F.L.S., and* G. S. West, *B.A., F.L.S., Hutchinson Student of St. John's College, Cambridge, Professor of Natural History, Royal Agricultural College, Cirencester.*

(Plates 17–22.)

Read 20th June, 1901.

A CERTAIN amount of work has been done on the Algæ of the various British possessions which constitute the Indian Empire, but the freshwater Algæ of the island of Ceylon have up to the present been almost completely overlooked. Contributions to the Alga-flora of Northern India, more particularly of Bengal, have been published by G. C. Wallich (1860), Lagerheim (1888), and W. B. Turner (1893); and a paper has also appeared on "Burmese Desmidieæ" by Joshua (1886).

A few Algæ from Ceylon have been issued in Wittrock and Nordstedt's 'Algæ Exsiccatæ,' but, so far as we know, the only freshwater ones are *Pithophora polymorpha*, Wittr., and *Sirogonium ceylanicum*, Wittr. Gomont, in his "Monographie des Oscillariées" (Ann. Sci. Nat. 7^{me} sér. xvi. 1892, p. 98–99), records *Plectonema Wollei*, Farlow, from "insulæ Ceylonæ (Grunow in herb. Thuret)"; and Grunow, in his "Algæ" in the 'Reise der Novara,' 1870, p. 40, describes *Cladophora clavuligera*, a minute species occurring attached to freshwater snails in the island of Ceylon. Also, in a recent paper by Borge, entitled "Ueber tropische und subtropische Süsswasser-Chlorophyceen" (Bih. till K. Sv. Vet.-Akad. Handl. Bd. xxiv. 1899, Afd. 3, no. 12), he mentions the following six species from Ceylon:—*Closterium parvulum*, Naeg.; *Cosmarium Botrytis*, Menegh.; *C. punctulatum*, Bréb.; *C. holmiense*, Lund.; *C. subspeciosum*, Nordst.; and *Staurastrum punctulatum*, Bréb. Curiously enough, all the six are common European Desmids. In addition to the above there is one species—*Hassallia ceylonica*—described by Schmidle in 'Hedwigia,' Bd. xxxix. 1900, p. 185, as occurring in Ceylon "am Mont Lavinia bei Colombo."

The Algæ which form the subject of this memoir were obtained from material collected by Mr. W. G. Freeman, B.Sc., F.L.S., in the island of Ceylon in 1896–97. He kindly placed at our disposal some fifty tubes of this material collected from very varied localities in the island. Representatives of almost all the families of freshwater Algæ were obtained, and two of the collections were somewhat rich in Desmidieæ.

The Desmids observed were essentially tropical in character, and present great similarity to those of Northern India, Burmah, and even Singapore and some of the East Indian Islands, a considerable percentage of the species being identical with Indian and Burmese forms. One striking feature is the presence in Ceylon of a relatively large number of the same species as occur in Madagascar. There is also a great resemblance between the Alga-flora of Ceylon and that of Northern Queensland, and the only two species known from Hong Kong (viz., *Triploceras gracile*, Bail., and *Pleurotænium Kayei*, Rabenh.) are each found both in Ceylon and in Queensland.

Some of the new species of the genus *Staurastrum* are deserving of special mention on account of their extraordinary forms; such are:—*S. columbetoides*, *S. tauphorum*, *S. ceylanicum*, *S. Freemanii*, *S. triforcipatum*, and *S. giganteum*.

The presence in Ceylon of *Phymatodocis irregulare*, Schmidle, a species recently described and known only from East Africa, is highly interesting, this genus having one species (*P. alternans*, Nordst.) confined to Brazil, one (*P. Nordstedtiana*, Wolle) known from the United States, Brazil, and New Zealand, and one (*P. irregulare*, Schmidle) now known from East Africa and Ceylon.

We look with regret upon the fact that so many of the descriptions and figures in W. B. Turner's "Freshw. Algæ of E. India" (K. Sv. Vet.-Akad. Handl. 1893, Bd. xxv. no. 5) are deplorably insufficient and inaccurate, and also that the tendency of the author was to found a species upon inadequate grounds—often upon a somewhat crude drawing in the manuscript G. C. Wallich left in the possession of the Royal Microscopical Society. This fact has rendered doubly difficult the task of identifying many of the Indian forms we have observed from Ceylon, and, unfortunately, it has caused other observers in many cases to have been led entirely astray in their interpretation of the nature of some of his species.

Very few Algæ were observed belonging to the families Confervaceæ and Ulotrichaceæ; this we are unable to account for, as many of the collections were from suitable localities for these plants.

Many other Algæ were observed in addition to those recorded in this paper, but, owing to the somewhat fragmentary nature of the specimens, it was not possible to positively identify them. Only those Diatoms have been recorded which we could easily identify. Numerous others were observed, but we thought it more advisable to leave them until some future date when sufficient time could be expended on their determination.

December, 1900.

Class FLORIDEÆ.

Family BATRACHOSPERMEÆ.

Genus BATRACHOSPERMUM, Roth.

1. BATRACHOSPERMUM ANGOLENSE, West & G. S. West, 'Welw. Afric. Alg.,' Journ. Bot. xxxv. 1897, p. 2.

Diam. fil. prim. (c. ramul. lat.) 134–162 μ, ad nod. 154–180 μ; diam. ax. fil. prim. 80–91 μ, ad nod. 92–100 μ.

Hab. In fast-running water, on rocks among Podostemons, Mahawelli Ganga.

The specimens were exactly like those from W. Africa, but a little smaller. The total length of the filaments was only 3–5 cm., but it is quite probable that the plants were young.

Class CHLOROPHYCEÆ.

Order *CONFERVOIDEÆ HETEROGAMÆ.*

Family COLEOCHÆTACEÆ.

Genus COLEOCHÆTE, Bréb.

2. COLEOCHÆTE SCUTATA, Bréb.; Rabenh. Flor. Europ. Algar. iii. p. 390.

Hab. In artificial tank, Peradeniya; some of the young plants had attached themselves to *Plectonema Wollei*, Farlow.

3. COLEOCHÆTE SOLUTA, Pringsh.; Rabenh. *l. c.* p. 389; Cooke, Brit. Freshw. Alg. p. 196, t. 88. fig. 3.

Hab. Paddyfield between Kosgoda and Urahaighasmahendai. In pond, Royal Botanic Garden, Peradeniya.

Genus APHANOCHÆTE, Berth.

4. APHANOCHÆTE PILOSISSIMA, Schmidle, in Hedwigia, xxxvi. 1897, p. 5, t. 2. figs. 1–3.

Hab. In artificial tank, Peradeniya.

Family ŒDOGONIACEÆ.

Genus BULBOCHÆTE, Alg.

5. BULBOCHÆTE NANA, Wittr. in Botaniska Notiser, 1872, p. 7, t. 1. fig. 9.

Crass. cell. veget. 14–17 μ; altit. 1–1½-plo major;
„ oogon. 25–28 μ; „ 31–38 μ;
„ androsporang. 8·5 μ; „ 7·5 μ.

Hab. Stream, Victoria Park, Colombo. Paddyfields, Heneratgodha. Paddyfield between Kosgoda and Urahaighasmahendai. In artificial tank, Peradeniya.

6. Bulbochæte elatior, Pringsh.; Hirn, in Act. Soc. Scient. Fennicæ, xxvii. 1900, p. 321, t. 51. fig. 327.

Crass. cell. veget. 11·5–14·5 μ; altit. $1\frac{1}{2}$–2-plo major;
,, oogon. 37–43 μ; ,, 32–35·5 μ;
,, androsporang. 9·5–11·5 μ; ,, 8 5–9·7 μ;
,, nannandr. 7·5– 8·5 μ; ,, 35 μ.

Hab. In artificial tank, Peradeniya.

7. Bulbochæte crassiuscula, Nordst. in Öfvers. K. Vet.-Akad. Förhandl. 1877, no. 4, p. 30, t. 3. figs. 14–15; Hirn, *l. c.* p. 341, t. 55. fig. 352.

Forma cellulis paullo angustioribus.

Crass. cell. veget. 12·5–13·5 μ; altit. 4–5-plo major;
,, oogon. 51–56 μ; ,, 44–52 μ;
,, nannandr. 11·5 μ; ,, 31 μ.

Hab. Paddyfield between Kosgoda and Urahaighasmahendai.

8. Bulbochæte minuta, sp. n. (Pl. 17. fig. 10.) *B.* dioica, nannandria, gynandrospora; oogoniis depresso-globosis, sub androsporangiis sitis, prope medium circumscissis; dissepimento cellularum suffultoriarum carenti vel juxta basin; oosporis oogonia complentibus, episporio lævi; androsporangiis unicellularibus, epigynis; nannandribus bicellularibus, in cellulis suffultoriis sedentibus, stipite duplo longiore quam spermogonium, incurvato.

Crass. cell. veget. 9·5–11·5 μ; altit. 2–3-plo major;
,, oogon. 29·5–34·5 μ; ,, 24–27 μ;
,, androsporang. 9·5–10·5 μ; ,, 6·5–9 μ;
,, nannandr. 6 μ; ,, 19 μ.

Hab. Paddyfields, Heneratgodha.

This species is considerably less than any other *Bulbochæte*; the oogonia are much depressed, and the bristles of the vegetative cells are very long.

9. Bulbochæte spirogranulata, sp. n. (Pl. 17. figs. 8, 9.) *B.* oogoniis oblongo-ellipsoideis, subpatentibus, episporio crasso longitudinaliter costato-crenulato; androsporangiis sparsis; cellulis suffultoriis dissepimento carentibus; membrana cellularum vegetativarum granulis parvis densis spiraliter dispositis ornata; setis longissimis.

Crass. cell. veget. 9·5–11·5 μ; altit. $3\frac{1}{2}$–5-plo major;
,, oogon. 20–24 μ; ,, 48–49 μ;
,, androsporang. 7·5 μ; ,, 9·5 μ.

Hab. Paddyfields, Heneratgodha.

The vegetative cells of this species are ornamented with minute granules spirally

arranged as in *Œdogonium punctatostriatum*, De Bary, *Œ. minus*, Wittr., &c. The oogonia are proportionately very long, and apparently possess a terminal pore.

Genus ŒDOGONIUM, Link.

10. ŒDOGONIUM CRYPTOPORUM, Wittr. Dispos. Œdog. Suec. 1870, p. 19; Prodr. Monog. Œdog. 1874, p. 7.

Var. VULGARE, Wittr. *l. c.*

Crass. cell. veget. 6·5–10 μ; altit. 3½–4-plo major;
" oogon. 22–24 μ; " 17·5–21 μ.
Hab. In artificial tank, Peradeniya.

11. ŒDOGONIUM PETRI, Wittr. Prodr. Monog. Œdog. 1874, p. 6; Hirn, in Act. Soc. Scient. Fennicæ, xxvii. 1900, p. 154, t. 24. fig. 127.

Crass. cell. veget. 5–8 μ; altit. 3–5-plo major;
" oogon. 21·5–25 μ; " 21–27 μ;
" oospor. 20·5–21·5 μ; " 16–18 μ.
Hab. Stream, Victoria Park, Colombo.

12. ŒDOGONIUM PLATYGYNUM, Wittr. Prodr. Monog. Œdog. 1874, p. 17.

Crass. cell. veget. 5–5·7 μ; altit. 4–5-plo major;
" oogon. 19·5–22 μ; " 18–19 μ.
Hab. Stream, Victoria Park, Colombo.

13. ŒDOGONIUM SUBOCTANGULARE, sp. n. (Pl. 17. figs. 1, 2.) *Œ.* monoicum, oogoniis singulis, rectangularibus, levissime inflatis; membrana oogonii crassa (3·4–3·8 μ) fuscescente; oosporis subrectangulari-ellipticis, oogonia complentibus angulis demptis; cellulis suffultoriis eadem forma ac cellulis vegetativis ceteris; spermogoniis bicellularibus, sparsis.

Crass. cell. veget. 50–54 μ; altit. 3½–4½-plo major;
" oogon. 53–67 μ; " 82–92 μ;
" oospor. 54–60 μ; " 73–85 μ;
" spermogon. 41–48 μ; " 25–27 μ.
Hab. Paddyfield between Kosgoda and Urahaighasmahendai.

The large size of this *Œdogonium* and the rectangular oogonia containing the suboctangular spores easily distinguish it from any other species.

14. ŒDOGONIUM PYRULUM, Wittr. in Botaniska Notiser, 1872, p. 2; Hirn, *l. c.* p. 158, t. xxv. fig. 136.

Crass. cell. veget. 8–11·5 μ; altit. 3–4½-plo major;
" oogon. 26–29 μ; " 27–34·5 μ;
" oospor. 23–37 μ; " 25–27 μ;
" spermogon. 8–9·5 μ; " 5·7 μ.
Hab. Stream, Victoria Park, Colombo.

Var. OBESUM, Wittr.
Hab. With the typical form.

15. ŒDOGONIUM ASTER, Wittr. in Botaniska Notiser, 1872, p. 4; Hirn, in Act. Soc. Scient. Fennicæ, xxvii. 1900, p. 198, t. 32. fig. 202.

Crass. cell. veget. 7·5–8 μ; altit. 9–11½-plo major;
„ oogon. 31–32·5 μ; „ 46–48 μ;
„ oospor. (s. spin.) 25·5–26 μ; „ 25·5–26 μ;
Long. spin. 2 μ.
Hab. Paddyfields, Heneratgodha.

16. ŒDOGONIUM STELLATUM, Wittr. in Öfvers. K. Vet.-Akad. Förh. 1870, no. 3, p. 129; Prodr. Monog. Œdog. 1874, p. 27, t. 1. fig. 15.

Crass. cell. veget. 13·5–17 μ; altit. 3–7-plo major;
„ oogon. 41 μ; „ 41 μ;
„ oospor. (s. spin.) 29–30·5 μ; „ 29–30 μ;
Long. dent. 3–3·5 μ.
Hab. Paddyfield between Kosgoda and Urahaighasmahendai.

17. ŒDOGONIUM SPIRALE, Hirn, *l. c.* p. 201, t. 33. fig. 206.

Var. ACUTUM, var. n. (Pl. 17. figs. 3–5.) Var. oosporis oogonia non complentibus, cum liris acutis prominentibus undulatis subanastomosis 5–6 de polo ad polum spiraliter ordinatis, in ambitu irregulariter et acute dentatis (dentibus distantibus).

Crass. cell. veget. 22–25 μ; altit. 3½–4½-plo major;
„ oogon. 46–54 μ; „ 54–60 μ;
„ oospor. (s. dent.) 37–42 μ; „ 27–42 μ;
„ nannandr. 9·5 μ; „ 52 μ.
Hab. Paddyfield between Kosgoda and Urahaighasmahendai.

This variety is sufficiently characterized by the more prominent, spirally arranged ridges on the oospores. These ridges are few in number, very sharp and prominent, and run in undulate spirals, often coalescing, from one pole of the oospore to the other.

18. ŒDOGONIUM LONGICOLLE, Nordst. Alg. aq. dulc. et Charac. Sandvicens. 1878, p. 20, t. 2. figs. 11–12.
Hab. With the preceding species.

Var. SENEGALENSE, Nordst. in Act. Univ. Lund. vol. xvi. 1880, p. 13, t. 16. fig. 23.
Hab. In artificial tank, Peradeniya. Paddyfields, Heneratgodha.

19. ŒDOGONIUM ELEGANS, sp. n. (Pl. 17. figs. 6, 7.) *Œ.* dioicum, nannandrium; oogoniis singulis, depresso-globosis, prope medium circumscissis, poro in circum-

scissione; oosporis transverse ellipsoideis, oogonia prope complentibus; cellulis suffultoriis non tumidis; nannandribus parvis oboviformibus unicellularibus, in oogoniis sedentibus; membrana cellularum vegetativarum dense et minute granulata, granulis spiraliter dispositis.

Crass. cell. veget. 6–8·5 μ; altit. 4–10-plo major;
„ oogon. 27–31 μ; „ 25·5–26 μ;
„ oospor. 25–28 μ; „ 18–19 μ;
„ nannandr. 5·5; „ 8·5 μ.

Hab. Paddyfields, Heneratgodha. Paddyfield between Kosgoda and Urahaighasmahendai.

This species differs from *Œdogonium punctatostriatum*, De Bary, in being nannandrous, and in its very much smaller size. From *Œ. minus*, Wittr., it is distinguished by being diœcious, nannandrous, and in its smaller size and relatively longer cells.

20. Œdogonium reticulatum, sp. n. *Œ.* cellulis elongatis; oogoniis ovoideo-globosis; oosporis globosis, oogonia non complentibus; membrana oosporæ areolis hexagono-reticulatis ornata.

Crass. cell. veget. 7·5–8 μ; altit. 8–13-plo major;
„ oogon. 35 μ; „ 41 μ;
„ oospor. 25 μ; „ 25 μ.

Hab. Paddyfields, Heneratgodha.

The material was very imperfect, but the extraordinary character of the oospores is somewhat noteworthy. Compare with *Œ. areyosporum*, Nordst. et Hirn, and *Œ. areolatum*, Lagerh.

Order *CONFERVOIDEÆ ISOGAMÆ.*

Family ULVACEÆ.

Genus Endoderma, Kütz.

21. Endoderma Reineckii, Schmidle, in Engler's Bot. Jahrb. xxiii. 1896, p. 259, cum fig.

Crass. cell. 15·5–44 μ.

Hab. In small pond, Peradeniya; epiphytic on *Pithophora radians.*

This plant has only previously been recorded from Samoa, and, curiously enough, it was there found epiphytic on *Pythophora Reineckii.*

Family ULOTRICHACEÆ.

Genus Hormiscia, Fries; emend. Aresch.

22. Hormiscia subtilis, De Toni, Syll. Algar. i. 1889, pp. 159–160. *Ulothrix subtilis*, Kuetz. Phyc. Germ. p. 197; Rabenh. Flor. Europ. Algar. iii. p. 365.

Var. TENERRIMA, Kirchn. *Ulothrix tenerrima,* Kuetz. Phyc. Germ. p. 197.

Crass. fil. 10·5 μ.

Hab. Among *Spirogyra* sp. in fast-running stream, Peradeniya.

Genus HERPOSTEIRON, Näg.

23. HERPOSTEIRON CRASSISETUM, sp. n. (Pl. 17. fig. 11.) Fila brevia, interdum ramosa, filis et ramis appressis; cellulæ depressæ suboblongæ vel irregulariter ellipticæ, supra dorsum cellulæ uniuscujusque setis erectis 1–2; setæ validæ filiformes, longitudinum variorum, angustæ basin versus sed crassiores sursum, tum gradatim attenuatæ ad apices acutos; seta unaquaque serie cellularum 4–8 formata, cellulis diametro 8–15-plo longioribus.

Diam. cell. 12·5–17 μ, altit. 6·5–7·5 μ; crass. set. 2·3–5 μ.

Hab. Paddyfields, Heneratgodha.

This species is characterized by the stout filamentous setæ, which very much resemble the branches of a *Chætophora* or a *Stigeoclonium.* The setæ are also narrower at their point of attachment to the cells than for some distance away from the base, and there are frequently two of them attached to one cell.

Genus NORDSTEDTIA, Borzì.

24. NORDSTEDTIA GLOBOSA, Borzì, in Nuova Notarisia, iii. Apr. 1892, p. 50. *Herposteiron globosum,* Nordst. Alg. aq. dulc. et Charac. Sandvic. 1878, p. 23, t. 2. figs. 22–23. *Aphanochæte globosa,* Wolle, Freshw. Alg. U.S. p. 119, t. 105. figs. 5, 6.

Diam. cell. 10·5–12·5 μ.

Hab. Paddyfields, Heneratgodha.

Family CONFERVACEÆ.

Subfamily CONFERVEÆ.

Genus MICROSPORA, Thur.; emend. Lagerh.

25. MICROSPORA FLOCCOSA, Thur. Rech. Zoosp. Algues, p. 12; Rabenh. Flor. Europ. Algar. iii. p. 321. *Conferva floccosa,* Agh.

Crass. fil. 13 μ.

Hab. Paddyfields, Heneratgodha.

Subfamily OPHIOCYTIEÆ.

Genus OPHIOCYTIUM, Naeg.

26. OPHIOCYTIUM CAPITATUM, Wolle, Freshw. Alg. U.S. p. 176, t. 158. figs. 3–7.

Var. LONGISPINUM, Lemmermann, in Hedwigia, xxxviii. 1899, p. 32. *O. cochleare,*

A. Br., var. *bicuspidatum*, Borge, forma *longispina*, Lemmerm. in Forschungsberichte Biol. Stat. Plön, 1896, p. 163 cum fig.

Long. cell. 60 μ; lat. cell. 6·5 μ; long. spin. 30–35 μ.

Hab. Running water, Royal Botanic Gardens, Peradeniya.

27. Ophiocytium parvulum, A. Br. Alg. Unicell. 1855, p. 55. *Brochidium parvulum*, Perty.

Lat. cell. 5·5 μ.

Hab. Stream, Victoria Park, Colombo.

Family CHROOLEPIDACEÆ.

Genus Trentepohlia, Mart.

28. Trentepohlia polycarpa, Nees, in Mont. Voyage de La Bonite, 1844–46, p. 16; De Toni, Syll. Algar. i. p. 238.

Filaments a little less than those of the typical form. Zoogonidangia numerous, sessile, and often three or four arising laterally from the same cell.

Crass. cell. veget. 19–22 μ; crass. zoogonidang. 29–36·5 μ.

Hab. On the side of a well, Pandure. Epiphytic on shrubs, &c., Hakgala Rock.

Probably the same species: zoogonidangia absent. Crass. cell. veget. 19–21·5 μ.

Hab. Bark of trees, Royal Botanic Gardens, Peradeniya.

Also from the same locality: crass. cell. veget. 27–32 μ.

29. Trentepohlia odorata, Wittr. Scand. Växt. p. 16, t. 16. *Chroolepus odoratum*, Agh.; Rabenh. Flor. Europ. Algar. iii. p. 372.

Crass. cell. veget. 12·5–17 μ; crass. zoogonidang. 22–25 μ.

Hab. Bark of trees, Royal Botanic Gardens, Peradeniya. Also on decomposing surface of gneiss, Matava.

30. Trentepohlia Montis-Tabulæ, De Toni, Syll. Alg. i. p. 240. *Chroolepus Montis-Tabulæ*, Reinsch, in Journ. Linn. Soc., Bot. xvi. (1877) p. 245.

Var. ceylanica, var. n. Var. filamentis crassioribus, ramis erecto-patentibus, cellulis brevioribus, diametro 2–2½-plo longioribus; membrana cellularum crassissima, oblique reticulata.

Crass. fil. 26–34 μ; crass. ram. 23–28 μ; crass. membr. cell. 3·5–6 μ.

Hab. Summit of Hakgala Rock, forming brilliant orange-red tufts on stems of *Osbeckia buxifolia* (only in very exposed situations).

31. Trentepohlia calamicola, De Toni et Levi; De Toni, Syll. Algar. i. p. 241. *Chroolepus calamicola*, Zeller, in Hedwigia, xii. 1873, p. 190.

Crass. cell. veget. 7·5–10 μ; crass. zoogonidang. 14·5–17 μ.

Hab. Bark of trees, Royal Botanic Gardens, Peradeniya.

32. TRENTEPOHLIA ABIETINA, Hansg. Prod. p. 86. *Chroolepus abietina*, Flotow; Rabenh. Flor. Europ. Algar. iii. p. 372.

Crass. cell. veget. 7–9·5 μ.

Hab. With the preceding species.

33. TRENTEPOHLIA BLEISCHII, Wille, in Pringsh. Jahrb. xviii. 1887, p. 432. *Chroolepus Bleischii*, Rabenh. Flor. Europ. Algar. iii. p. 373.

Crass. cell. veget. 32·5–39 μ.

Hab. With the preceding species.

34. TRENTEPOHLIA UMBRINA, Born. ex Wille, *l. c.* p. 426. *Chroolepus umbrinus*, Kuetz.; Rabenh. Flor. Europ. Algar. iii. p. 426.

Crass. cell. veget. 13·5–19 μ.

Hab. Bark of trees, Peradeniya.

Family CLADOPHORACEÆ.

Genus CLADOPHORA, Kuetz.

35. CLADOPHORA GLOMERATA, Kuetz. Phyc. Germ. p. 212; Cooke, Brit. Freshw. Alg. p. 143, t. 56. fig. 1.

Hab. In running water, Royal Botanic Gardens, Peradeniya.

36. CLADOPHORA INCURVATA, sp. n. (Pl. 17. figs. 12, 13.) *C.* magna, cæspitibus viridibus, in partem inferiorem simplicibus, sursum ramosis, ramis fasciculatim et dense ramulosis, ramulis ultimis gracillime incurvatis; cellulis primariis circiter diametro 3–6-plo longioribus, cellulis ramulorum ultimorum diametro 2–3-plo longioribus; membrana incrassata et striata.

Crass. fil. primar. 121–138 μ; crass. ram. 57–86 μ; crass. ramul. ultim. 35–50 μ; crass. membr. cell. usque ad 17 μ.

Hab. Pond, Victoria Park, Colombo.

Genus CHÆTOMORPHA, Kuetz.

37. CHÆTOMORPHA LINUM, Kuetz. Phyc. Germ. p. 204. *Conferva Linum*, O. F. Müll. *Chætomorpha sutoria*, Berk.

Crass. fil. 116–154 μ.

Hab. Muddy flats, estuary, Bentota.

Family PITHOPHORACEÆ.

Genus PITHOPHORA, Wittr.

38. PITHOPHORA RADIANS, West & G. S. West, 'Welw. Afric. Alg.,' Journ. Bot. xxxv. 1897, p. 36.

Crass. fil. et ram. primar. 79–100 μ; long. spor. intercal. 141–216 μ, lat. 116–133 μ; long. spor. terminal. 280–300 μ, lat. 108–120 μ.

Hab. In small pond, Peradeniya.

Order *CONJUGATÆ.*

Family ZYGNEMACEÆ.

Subfamily MESOCARPEÆ.

Genus MOUGEOTIA, Agh.

39. MOUGEOTIA ROBUSTA, Wittr. *Mesocarpus robustus*, De Bary, Conj. t. 2. fig. 16.

Var. BIORNATA, Wittr. in Wittr. & Nordst. Alg. Exsicc. no. 615.
Crass. cell. veget. 26–29 μ; long. spor. 43 μ; lat. spor. 36–38 μ.
Hab. Paddyfields, Heneratgodha.

Subfamily ZYGNEMEÆ.

Genus SPYROGYRA, Link.

40. SPIROGYRA NEGLECTA, Kuetz. Sp. Algar. 1849, p. 441; Rabenh. Flor. Europ. Algar. iii. p. 248; Petit, Spirog. de Paris, p. 26, t. 9. figs. 1–5. *Zygnema neglecta*, Hass.
Crass. cell. veget. 53–63 μ; long. zygosp. 75–94 μ; lat. zygosp. 49–57 μ.
Hab. In running water, Royal Botanic Gardens, Peradeniya.

41. SPIROGYRA DECIMINA, Kuetz. Phyc. Germ. p. 223; Petit, Spirog. de Paris, p. 25, t. 8. figs. 1–3.
Crass. cell. veget. 32–36 μ; long. zygosp. 70–73 μ; lat. zygosp. 43–46 μ.
Hab. Among Podostemons, Mahawelli Ganga, near Peradeniya.

Family DESMIDIACEÆ.

Genus GONATOZYGON, De Bary.

42. GONATOZYGON RALFSII, De Bary, Conj. 1858, p. 76, t. 4. figs. 23–25.
Long. 144–249 μ; lat. 9·5–11·5 μ.
Hab. Paddyfields, Heneratgodha and Pandure. Pond, Royal Botanic Gardens, Peradeniya.

43. GONATOZYGON PILOSUM, Wolle, in Bull. Torr. Bot. Club, ix. 1882, p. 27, t. 13. fig. 16; Desm. U.S. p. 22, t. 1. fig. 2.
Long. 230 μ; lat. 11 μ.
Hab. Paddyfield between Kosgoda and Urahaighasmahendai.

Genus CYLINDROCYSTIS, Menegh.

44. CYLINDROCYSTIS MINUTISSIMA, W. B. Turn. in K. Sv. Vet.-Akad. Handl. xxv. 1893, no. 5, p. 16, t. 1. fig. 24.

Long. 12–14 μ; lat. 6·5–7·5 μ; lat. constrict. 5·3–5·6 μ.

Hab. Paddyfields, Heneratgodha.

45. CYLINDROCYSTIS ANGULATA, West & G. S. West, 'N. Amer. Desm.,' Trans. Linn. Soc., ser. 2, Bot. vol. v. 1896, p. 237, t. 13. figs. 25, 26.

Long. 74 μ; lat. 31 μ; lat. apic. 14·5 μ.

Hab. Among *Spirogyra* sp. in the little muddy backwaters, Mahawelli Ganga.

46. CYLINDROCYSTIS PYRAMIDATA, sp. n. (Pl. 18. figs. 1, 2.) *C.* parva, 1½-plo longior quam lata, leviter constricta ad medium; semicellulæ ovato-pyramidatæ, polis late rotundatis; membrana glabra; a vertice visæ circulares; pyrenoidibus singulis conspicuis.

Long. 34·5–37 μ; lat. 22–25 μ; lat. constrict. 21–22·5 μ.

Hab. Paddyfield between Kosgoda and Urahaighasmahendai. On rocks and also among Podostemons, Mahawelli Ganga.

Genus PENIUM, Bréb.

47. PENIUM DIGITUS, Bréb. in Ralfs, Brit. Desm. p. 150, t. 25. fig. 3. *Closterium lamellosum*, Bréb. *Penium lamellosum*, Kuetz. *P. navigium*, W. B. Turn. in K. Sv. Vet.-Akad. Handl. xxv. 1893, no. 5, p. 17, t. 1. fig. 9.

Hab. Paddyfields, Heneratgodha. Paddyfield between Kosgoda and Urahaighasmahendai.

Var. CONSTRICTUM, West, in Journ. Linn. Soc., Bot. vol. xxix. 1892, p. 127.

Long. 420 μ; lat. 65 μ; lat. med. 62 μ.

Hab. Paddyfield between Kosgoda and Urahaighasmahendai.

48. PENIUM LANCEOLATUM, W. B. Turn. in K. Sv. Vet.-Akad. Handl. xxv. 1893, no. 5, p. 17, t. 1. fig. 7.

Var. SUBCYLINDRICUM, var. n. (Pl. 18. fig. 5.) Var. cellulis paullo longioribus, lateribus subparallelis subito attenuatis prope apices, apicibus rotundo-truncatis, constrictione mediana angustiore.

Long. 134 μ; lat. max. 35 μ; lat. apic. circ. 15 μ; lat. isthm. 30 μ.

Hab. Paddyfields, Heneratgodha.

This variety is distinguished from *Penium Clevei*, Lund., by the different form of its cells and by the absence of the small apical granulations.

49. Penium heterotaphridium, sp. n. (Pl. **18.** figs. 3, 4.) *P.* mediocre, cellulis diametro pæne 3-plo longioribus, in medio modice et subgradatim constrictis, leviter attenuatis polos versus, polis truncato-retusis; membrana scrobiculata, scrobiculis prope medium cellularum majoribus et sparsis subregulariter ordinatis, iis polos versus minoribus confertis et in seriebus transversis ordinatis; a vertice visæ circulare.

Zygospora subglobosa, glabra.

Long. 69–73 μ; lat. 25–29 μ; lat. apic. circ. 13·5–15 μ; lat. med. 22–24 μ; diam. zygosp. 36–40 μ.

Hab. Paddyfields, Heneratgodha.

The nearest species to this is *P. adelochondrum*, Elfv., from which it differs in its larger size, its greater constriction, its retuse poles, and in the peculiarly scrobiculated cell-wall. It may also be compared with *P. lagenarioides*, Roy, and *P. lagenarioides* var. *sydneyense*, Racib.

50. Penium variolatum, West & G. S. West, 'Welw. Afric. Alg.,' Journ. Bot. xxxv. 1897, p. 77, t. 368, fig. 23.

Forma cellulis paullo brevioribus, apicibus levissime retusis. Long. 26·5–27·5 μ; lat. 8–9 μ. (Pl. **18.** fig. 10.)

Hab. Paddyfields, Heneratgodha.

51. Penium inconspicuum, West, in Journ. Roy. Micr. Soc. 1894, p. 4, t. 1. figs. 6, 7.

Long. 17 μ; lat. 5·4 μ.

Hab. Paddyfields, Heneratgodha.

52. Penium spinospermum, Joshua, in Journ. Bot. xxiii. 1885, p. 23, t. 254. fig. 10.

Forma minor. Long. 25–29 μ; lat. 14·5–15·5 μ; diam. zygosp. c. proc. 26–27·5 μ. (Pl. **18.** figs. 8, 9.)

Hab. Paddyfields, Heneratgodha.

53. Penium navicula, Bréb. in Mém. Soc. Sci. Nat. Cherbourg, iv. 1856, p. 146, t. ii. fig. 37.

Hab. Paddyfield between Kosgoda and Urahaighasmahendai. Paddyfields, Heneratgodha. Pond, Victoria Park, Colombo.

54. Penium Libellula, Nordst. in Vidensk. Meddel. naturh. Foren. Kjöbenhavn, 1888, p. 184. *Closterium Libellula*, Focke, Physiolog. Stud. 1847, p. 58, t. 3. fig. 29. *Penium closterioides*, Ralfs, Brit. Desm. 1848, p. 152, t. 34. fig. 4.

Hab. Paddyfields, Heneratgodha.

Forma interrupta, West, in Journ. Roy. Micr. Soc. 1892, p. 721.

Hab. With the typical plant.

Var. INTERMEDIUM, Roy & Biss. in Ann. Scot. Nat. Hist. 1894, p. 252.

Long. 132 μ; lat. 21 μ.

Hab. Paddyfield between Kosgoda and Urahaighasmahendai.

55. PENIUM SPIROSTRIOLATUM, Barker, in Quart. Journ. Micr. Sci., New Ser. ix. 1869, p. 194; G. S. West, in Journ. Linn. Soc., Bot. xxvii. 1899, pp. 377–380, t. 8. figs. 1–12. *Closterium spiraliferum*, Jacobs. in Botan. Tidsskrift, Kjöbenhavn, 1875, p. 177, t. 7. fig. 8. *Penium Haynaldii*, Schaarschm. in Magyar Tudom. Akad. math. és Természettud. Közlemények, xviii. 1883, p. 277, t. 1. fig. 20. *P. Royanum*, W. B. Turn.; *P. scandinavicum*, W. B. Turn. in K. Sv. Vet.-Akad. Handl. xxv. 1893, no. 5, pp. 165, 166, t. 23. figs. 3–7.

Hab. Paddyfields, Heneratgodha. Paddyfield between Kosgoda and Urahaighasmahendai.

56. PENIUM SPIROSTRIOLATIFORME, sp. n. (Pl. **18**. fig. 6.) *P.* mediocre, elongatum, rectum (vel subrectum), cylindricum, cellulis diametro 34-plo longioribus, marginibus lateralibus parallelis, levissime attenuatis prope apices, apicibus dilatatis rotundo-truncatis; membrana luteola, valde spirostriatis; suturis variabilibus (circ. 10) irregulariter dispositis.

Long. 264 μ; lat. 7·5 μ.

Hab. Paddyfields, Heneratgodha.

This extraordinary plant bears a considerable resemblance to *P. spirostriolatum*, Barker, but it is at once distinguished by its narrow form, its proportionately great length and uniform breadth. Division can take place at any part of the cell, this being shown by the variable number of transverse sutures, in all respects similar to those of *P. spirostriolatum*. The apices of the cells are markedly dilated, and no traces of a network were seen, such as is often present at or near the apices of *P. spirostriolatum*.

It might also be compared with some of the spirally-marked forms of *Closterium angustatum*, from which, however, it is readily distinguished.

It is undoubtedly a true species of *Penium* of the same nature as *P. spirostriolatum*.

57. PENIUM MINUTUM, Cleve, in Öfvers. K. Vet.-Akad. Förh. 1863, no. 10, p. 493. *Docidium minutum*, Ralfs, Brit. Desm. p. 158, t. 26. fig. 5.

Hab. Paddyfields, Heneratgodha. Paddyfield between Kosgoda and Urahaighasmahendai.

Var. GRACILE, Wille, in Christian. Forh. Vidensk.-Selsk. 1880, no. 11, p. 51, t. 2. fig. 33.

Hab. Paddyfields, Heneratgodha.

Var. ELONGATUM, nob. *Docidium elongatum*, West, in Journ. Roy. Micr. Soc. 1890, p. 284, t. 5. fig. 17.

Long. 257 μ; lat. 8 μ. (Pl. **18**. fig. 7.)

Hab. With the preceding variety.

Genus Closterium, Nitzsch.

58. Closterium subcompactum, sp. n. (Pl. **18.** fig. 11.) *C.* subparvum, cellulis diametro 3¼–3½-plo longioribus, subrectis, leviter attenuatis polos versus, dorso modice convexo, ventre subrecto, polis crassis truncato-rotundatis, levissime dilatatis et cum nodulo late incrassato, in medio cellularum levissime constricto; membrana glabra achroa; pyrenoidibus 2–3 in semicellula unaquaque.

Long. 99–100 μ; lat. 29–31 μ; lat. apic. 15–18 μ.

Hab. Paddyfield between Kosgoda and Urahaighasmahendai.

This species somewhat resembles *C. compactum*, Nordst. (in K. Sv. Vet.-Akad. Handl. xxii. 1888, no. 8, p. 68, t. 3. fig. 25), but is smaller, less curved, and has much broader and differently-formed apices. The median constriction is also peculiar.

It might also be compared with *C. Legumen*, West & G. S. West (in Journ. Linn. Soc., Bot. xxxiii. 1897, p. 158, t. 8. figs. 5–7), a species known from Singapore and West-Central Africa; it is distinguished by being relatively shorter and more robust, by the thicker and slightly dilated apices, and by the median constriction.

59. Closterium striolatum, Ehrenb.; Ralfs, Brit. Desm. p. 170, t. 29. fig. 2.

Long. 264–277 μ; lat. 22–23 μ; lat. apic. 9–10·5 μ.

Hab. Paddyfields, Heneratgodha. Paddyfield between Kosgoda and Urahaighasmahendai.

Var. robustum, var. n. (Pl. **18.** fig. 13.) Var. robustum, cellulis crassioribus, diametro 7–8-plo longioribus, apicibus crassioribus triangulo-rotundatis; membrana crassa, striis validis 14 (visis).

Long. 201 μ; lat. 26 μ; lat. apic. 12·5 μ.

Hab. Paddyfields, Heneratgodha.

60. Closterium intermedium, Ralfs, Brit. Desm. 1848, p. 171, t. 29. fig. 3.

Long. 234 μ; lat. 20 μ; lat. apic. 10·5 μ.

Hab. Paddyfields, Heneratgodha.

61. Closterium anastomosum, sp. n. (Pl. **18.** figs. 24–26.) *C.* submediocre, cellulis diametro 21–24-plo longioribus, levissime curvatis, lateribus subparallelis, levissime attenuatis polos versus, polis subrotundo-truncatis (indistincte subdilatatis); membrana luteo-fuscescente, delicate striolata, striis paucis irregulariter anastomosis; pyrenoidibus in serie unica in semicellula unaquaque 7–10; locellis apicalibus terminalibus et corpusculis 2–3 includentibus.

Long. 217–284 μ; lat. 10·5–12 μ; lat. apic. 7·5–9·5 μ.

Hab. Paddyfields, Heneratgodha.

This plant most nearly approaches *C. Toxon*, West, but is distinguished by its greater robustness, its less attenuated cells, the colour and remarkable striolation of the cell-wall. It may also be compared with *C. Ulna*, Focke (= *C. directum*, Arch.).

It differs from *Closterium juncidum*, Ralfs, in its curvature, in the truncate and relatively broader apices, and in its peculiar striolation.

62. Closterium gracile, Bréb. 1839; in Mém. Soc. Sci. Nat. Cherbourg, iv. 1856, p. 155, t. 2. fig. 45. *C. limneticum*, Lemmermann, in Plöner Forschungsberichten, Teil vii. 1899, p. 28, t. 2. figs. 39–41.

Hab. Paddyfield between Kosgoda and Urahaigbasmahendai.

Var. tenue, nob. *C. limneticum*, var. *tenue*, Lemm. *l. c.* t. 2. figs. 42–44; *cfr.* West & G. S. West, in Journ. Bot. xxxviii. 1900, p. 290.

Long. 69–110 μ; lat. 2·5–3·5 μ. (Pl. **18.** figs. 22, 23.)

Hab. Paddyfields, Heneratgodha.

Lemmermann's measurements of the length of *C. limneticum*, var. *tenue*, are obviously wrong; he gives it as "255–308 μ," whereas his figures measure 80–90 μ, the latter agreeing with our own measurements.

63. Closterium attenuatum, Ehrenb. 1838; Ralfs, Brit. Desm. 1848, p. 169, t. 29. fig. 5.

Long. 432 μ; lat. 42 μ.

Hab. Paddyfields, Heneratgodha.

64. Closterium acerosum, Ehrenb. 1831; Ralfs, *l. c.* p. 164, t. 27. fig. 2.

Long. 790 μ; lat. 50 μ.

Hab. In small pond, Peradeniya. Paddyfields, Heneratgodha.

65. Closterium lineatum, Ehrenb. 1834; Ralfs, *l. c.* p. 173, t. 30. fig. 1.

Long. 750 μ; lat. 25 μ; lat. apic. 9·5 μ.

Hab. Pond, Victoria Park, Colombo.

66. Closterium Delpontii, Wolle, in Bull. Torr. Bot. Club, xii. 1885, p. 2. *C. Ralfsii*, Bréb., var. *Delpontii*, Klebs, 1879. *C. crassum*, Delp. (non Rabenh.).

Long. 422 μ; lat. 23 μ; lat. apic. 4·8 μ.

Hab. Paddyfields, Heneratgodha.

Var. elongatum, var. n. (Pl. **18.** fig. 20.) Var. cellulis elongatis, diametro circiter 35-plo longioribus; striis 11 (visis).

Long. 565 μ; lat. 15·5 μ; lat. apic. 4·5 μ.

Hab. With the typical form.

67. Closterium Ralfsii, Bréb. in Jenner, Fl. Tunbr. Wells, p. x; Ralfs, Brit. Desm. 1848, p. 174, t. 30. fig. 2.

Var. hybridum, Rabenh. Flor. Europ. Algar. iii. p. 135.

Long. 700 μ; lat. 38 μ; lat. apic. 11 μ.

Hab. Paddyfield between Kosgoda and Urahaighasmahendai. Paddyfields, Heneratgodha.

68. Closterium rostratum, Ehrenb. 1832; Ralfs, Brit. Desm. 1848, p. 175, t. 30. fig. 3.

Forma angustior, Gutw. in Rozpraw. Wydz. matem.-przyr. Akad. Umiej. Krakow, xxxiii. 1896, p. 42, t. 6. fig. 23.

Long. 232 μ; lat. 13·5 μ; lat. apic. 3·5 μ.

Hab. Pool in glen by roadside, near Bandarawella (altit. 4000–5000 ft.).

69. Closterium Kützingii, Bréb. in Mém. Soc. Sci. Nat. Cherbourg, iv. 1856, p. 156, t. ii. fig. 40.

Var. vittatum, Nordst. in Botaniska Notiser, 1887, p. 163; in K. Sv. Vet.-Akad. Handl. xxii. 1888, no. 8, p. 70, t. 3. fig. 20.

Forma duplo-minor. Long 236 μ; lat. 9 μ. (Pl. 18. fig. 21.)

Hab. Paddyfields, Heneratgodha.

70. Closterium setaceum, Ehrenb. 1834; Ralfs, Brit. Desm. 1848, p. 176, t. 30. fig. 4.

Hab. With the preceding species.

71. Closterium moniliferum, Ehrenb. 1838; Ralfs, *l. c.* p. 166, t. 28. fig. 3.

Hab. On rocks and among Podostemons, Mahawelli Ganga, near Peradeniya.

72. Closterium Leibleinii, Kuetz. in Linnæa, viii. 1833, p. 596, t. 18. fig. 79; Ralfs, *l. c.* p. 167, t. 28. fig. 4.

Lat. 17 μ; apicibus 107 μ inter se distantibus.

Hab. Paddyfield between Kosgoda and Urahaighasmahendai.

73. Closterium pleurodermatum, sp. n. (Pl. 18. fig. 12.) *C.* subparvum, cellulis diametro circiter 7-plo longioribus, curvatis, dorso arcuato, ventre in medio leviter tumido, attenuatis polos versus, polis oblique rotundatis; membrana lutea (vel fuscescente) costata, costis visis 9.

Lat. 22 μ; apicibus inter se distantibus 138–142 μ.

Hab. Paddyfields, Heneratgodha. Stream, Victoria Park, Colombo.

In outward form this plant somewhat resembles *C. Leibleinii*, Kuetz., but the obliquely rounded apices and the costate cell-wall are quite distinctive.

74. Closterium subporrectum, sp. n. (Pl. 18. figs. 14–16.) *C.* subparvum, valde arcuatum; cellulis angustis, sensim attenuatis polos versus, polis angustis obtusis; membrana rufescente, valde costata, costis visis 4.

Lat. 11·5–12·5 μ; apicibus 125–180 μ inter se distantibus.

Hab. Paddyfields, Heneratgodha.

This species approaches *Closterium porrectum*, Nordst., but is distinguished by its smaller size, its narrower cells, and the fewer number of the strong costæ. The curvature of the cells varies very considerably.

75. Closterium nematodes, Joshua, in Journ. Linn. Soc., Bot. xxi. 1886, p. 652, t. 22. figs. 7–9.

Lat. 18 μ; apicibus 172 μ inter se distantibus.

Hab. Paddyfields, Pandure and Heneratgodha. Also between Kosgoda and Urahaighasmahendai.

76. Closterium validum, sp. n. (Pl. 18. fig. 19.) *C.* submediocre, robustum; cellulis diametro 7–8-plo longioribus, valde curvatis, sensim attenuatis polos versus, polis latis triangularo-subrotundatis; membrana rufescente, valde striata, striis visis circ. 15.

Lat. 32 μ; apicibus 176 μ inter se distantibus.

Hab. Paddyfield between Kosgoda and Urahaighasmahendai.

Perhaps the nearest species to this is *C. lagoense*, Nordst., but *C. validum* is much larger and not so attenuated towards the poles. The apices are distinctly angular, but not dilated, and the striolations of the cell-wall are very much stronger.

Compare also with *Cl. Isidis*, Cohn (' Desm. Bong.,' Festschrift natur. Ges. zu Halle, 1879, p. 6, t. 11. fig. 15).

77. Closterium Dianæ, Ehrenb. 1838; Ralfs, Brit. Desm. 1848, p. 168, pl. 28. fig. 5.

Hab. Paddyfields, Pandure. Paddyfield between Kosgoda and Urahaighasmahendai.

78. Closterium Pseudodianæ, Roy, in Scot. Nat. x. 1890, p. 201; 'Scott. Desm.,' Ann. Scot. Nat. Hist. 1894, t. 1. fig. 4.

Small forms :—lat. 7·6–8 μ; apicibus 119–129 μ inter se distantibus.

Hab. Paddyfields, Heneratgodha.

79. Closterium calosporum, Wittr. in Nov. Act. Soc. Upsala, ser. 3, vii. 1869, p. 23, t. 1. fig. 11.

Lat. 12 μ; apic. 106 μ inter se distantibus.

Hab. Paddyfields, Heneratgodha.

80. Closterium Cynthia, De Not. Desm. Ital. p. 65, t. 7. fig. 71.

Hab. Pond, Victoria Park, Colombo. Paddyfields, Heneratgodha. Paddyfield between Kosgoda and Urahaighasmahendai. Muddy bottom of pool at foot of Hakgala Rock.

81. Closterium Venus, Kuetz. Phyc. Germ. 1845, p. 130.

Hab. Paddyfield between Kosgoda and Urahaighasmahendai. Paddyfields, Pandure. In tank, Peradeniya.

82. CLOSTERIUM INCURVUM, Bréb. in Mém. Soc. Sci. Nat. Cherbourg, iv. 1856, p. 150, t. 2. fig. 47.

Lat. 6·5 μ; apicibus 34 μ inter se distantibus.

Hab. Paddyfields, Heneratgodha.

83. CLOSTERIUM EXIGUUM, sp. n. (Pl. **18.** figs. 17, 18.) *C.* minutum, valde arcuatum, cellulis angustis, sensim attenuatis polos versus, polis angustis acutis; membrana achroa glabra; pyrenoidibus in semicellula unaquaque 2; locellis apicalibus subterminalibus et corpuscula singula inclusa.

Lat. 4·8–5·2 μ; apicibus 79–82 μ inter se distantibus.

Hab. Paddyfields, Heneratgodha.

This species is perhaps nearest to *C. parvum*, Naeg., var. *angustum*, West & G. S. West, but differs in its smaller size, in being narrower, in the greater attenuation of the poles, and in the nature of the apical locellus, which contains only one moving granule.

It should be compared with *C. Venus*, Kuetz.

Genus DOCIDIUM, Bréb.

84. DOCIDIUM BACULUM, Bréb. in Ralfs, Brit. Desm. 1848, p. 158, t. 33. fig. 5.

Long. 148–280 μ; lat. ad bas. semicell. 9·5–12·5 μ; lat. ad med. semicell. 7·8–9·7 μ; lat. ad apic. 4·8–6 μ.

Hab. Paddyfields, Heneratgodha.

85. DOCIDIUM MANUBRIUM, West & G. S. West, in Trans. Linn. Soc., Bot. ser. 2, vol. v. 1895, p. 44, t. 5. fig. 31.

Var. TENUE, var. n. (Pl. **19.** fig. 11.) Var. semicellulis angustioribus, lateribus parallelis, inflatione basali prominentiore; granulis (et plicationibus) 16 (visis 9) ad basin ut in forma typica.

Long. 375 μ; lat. ad bas. semicell. 22 μ; lat. ad med. semicell. 18 μ; lat. ad apic. 15 μ.

Hab. With the preceding species.

Genus PLEUROTÆNIUM, Näg.

86. PLEUROTÆNIUM NODOSUM, Lund. in Nov. Act. Sci. Upsala, ser. 3, viii. 1871, p. 90. *Docidium nodosum*, Bail. in Ralfs, Brit. Desm. 1848, p. 218, t. 35. fig. 8.

Hab. Paddyfield between Kosgoda and Urahaighasmahendai.

87. PLEUROTÆNIUM KAYEI, Rabenh. Flor. Europ. Algar. iii. p. 439. *Docidium Kayei*, Arch. in Quart. Journ. Micr. Sci. 1865, p. 296, t. 7. fig. 2. *Docidium horridum*, Borge, in Bih. till K. Sv. Vet.-Akad. Handl. xxii. 1896, Afd. 3, no. 9, p. 28, t. iv. fig. 55.

Long. 254–280 μ; lat. bas. semicell. sine spin. 49–52 μ, cum spin. 60–67 μ; lat. apic. semicell. sine spin. 31–33 μ, cum spin. 40–42 μ. (Pl. **18.** figs. 33, 34.)

Hab. With the preceding species.

Dr. Lauder's drawing of this species given by Archer (Quart. Journ. Micr. Sci. 1865, t. 7. fig. 2) is a poor representation of the plant, and as that was all Archer had to go by, his description is also not quite accurate. There are no "hyaline quadripartite spines," the conical spines being arranged in pairs. The number of pairs of spines in each whorl varies considerably. Mr. Kaye informed Archer that there were 10 prominences in each whorl; Borge says 15–17 pairs of spines at the base, and 7–12 spines at the apex for his *Docidium horridum*. We find 12 in each whorl, including the apex.

There is no question that *D. horridum*, Borge, is identical with *D. Kayei*, Arch.

88. Pleurotænium annulatum, West & G. S. West, in Journ. Bot. xxxvi. 1898, p. 332. *Docidium annulatum*, Joshua, in Journ. Linn. Soc., Bot. xxi. 1886, p. 651, t. 25. fig. 13. *Docidium egregium*, W. B. Turn. in K. Sv. Vet.-Akad. Handl. xxv. 1893, no. 5, p. 34, t. 2. figs. 14, 15.

Long. 234–318 μ; lat. ad bas. semicell. 18–20 μ, lat. ad med. 17·5–18 μ, lat. apic. 13·5–16 μ.

Hab. Paddyfields, Heneratgodha. Paddyfield between Kosgoda and Urahaighasmahendai.

We have already shown that *Docidium egregium*, W. B. Turn., is identical with *Pleurotænium annulatum*, and also that its cell-wall possesses shallow internal pits. These pits are of a regular broadly-rounded form, and are not so well marked as those of *P. trochiscum* or *P. doliforme*, being almost invisible under a magnification of 250 diameters. We take the opportunity of giving a careful drawing of one of Joshua's Burmese specimens (Pl. **19.** fig. 5) for comparison with a specimen from Ceylon (Pl. **19.** fig. 6).

89. Pleurotænium trochiscum, West & G. S. West, in Trans. Linn. Soc., ser. 2, Bot. vol. v. 1896, p. 235, t. 13. figs. 4, 5.

Long. 265–309 μ; lat. ad bas. semicell. 20–26 μ; lat. ad med. semicell. 17–22 μ; lat. apic. 16–19·5 μ. (Pl. **19.** figs. 7, 8.)

Hab. Paddyfields, Heneratgodha. Paddyfield between Kosgoda and Urahaighasmahendai.

Although the specimens from Ceylon were very variable in size, the largest did not equal in dimensions any of the American examples. In all cases the pitted marks were more regular towards the apices of the cells than in any specimen we have previously seen, and in some they showed a tendency to coalesce into annular bands. A few examples were noticed in which minute scrobiculations were present on the cell-wall between the pits, thus proving the close relationship between this species and *P. annulatum*.

90. Pleurotænium doliforme, sp. n. (Pl. **19.** figs. 9, 10.) *P.* submagnum, diametro $3\frac{3}{4}$–$4\frac{1}{2}$-plo longius; semicellulæ ovato-doliformes, levissime productis apices versus, apicibus truncatis tuberculatis, tuberculis parvis 10 (visis 6) infra apicem; membrana

annulis 5–7 impressionum irregularium subquadrangularium vel subrectangularium (nunquam in series longitudinaliter dispositis), in parte superiore semicellularum impressionibus confluentibus et multe irregularibus, annulo basali impressionum irregulari et confluente; impressiones partes tenuissimæ membranæ sunt (ut in *Pleurotænio trochisco*).

Long. 259–276 μ; lat. ad bas. semicell. 38–54 μ; lat. ad apic. semicell. 27–34 μ; lat. max. 61–71 μ.

Hab. Paddyfields, Heneratgodha. Paddyfield between Kosgoda and Urahaighasmahendai.

This *Pleurotænium* is of the same nature as *P. trochiscum*, possessing a number of somewhat irregularly quadrate or rectangular pits arranged in transverse rings. The ring at the base of each semicell consists of much smaller and more irregular pits which are confluent round the base. The rings towards the apex are also confluent, forming elongated longitudinally placed pits of a very irregular outline, often confluent round the apex. The pitted marks of this species exhibit no trace of a longitudinal arrangement, but are disposed more after the manner of the bricks or stones in a wall. The arrangement of the pits and the greatly inflated semicells, which are entirely destitute of a basal inflation, readily distinguish this species.

91 PLEUROTÆNIUM PARALLELUM, West & G. S. West, in Trans. Linn. Soc., ser. 2, Bot. vol. v. 1895, p. 45, t. 5. fig. 34.

Long. 695 μ; lat. ad bas. semicell. 47 μ; lat. ad apic. semicell. 46·5 μ.

Hab. Paddyfields, Heneratgodha.

92. PLEUROTÆNIUM PERLONGUM, sp. n. (Pl. 19. figs. 1, 2.) *P.* mediocre, elongatum; cellulis concatenatis, diametro 28–36-plo longioribus; semicellulæ cylindricæ, inflatione prominenti ad basin et undulis circiter 3 supra basin, lateribus parallelis, apicibus leviter dilatatis, tuberculis longitudinaliter ellipticis parvis 30–32 (visis 16–17) instructis.

Long. 463–590 μ; lat. ad bas. semicell. 19·5–21 μ; lat. ad med. semicell. 14·5–15·5 μ; lat. ad apic. 20–21·5 μ.

Hab. Paddyfields, Heneratgodha.

The extraordinary length of this species, together with the character of the base of the semicells and the dilated apices, are sufficiently characteristic. There are also more tubercles in the apical ring than is generally the case in narrow species of this class of *Pleurotænia.* The cells are usually somewhat curved, and are joined together in filaments, the tuberculated apex of one cell being closely applied to the tuberculated apex of the next.

93. PLEUROTÆNIUM ELATUM, Borge, in Bih. till K. Sv. Vet.-Akad. Handl. xxiv. 1899, Afd. 3, no. 12, p. 16. *Docidium elatum,* W. B. Turn. in K. Sv. Vet.-Akad. Handl. xxv. 1893, no. 5, p. 27, t. 2. fig. 16. *Docidium robustum,* W. B. Turn. *l. c.* p. 27, t. 2. fig. 8.

After carefully considering Turner's figures and descriptions of *Docidium elatum* and *D. robustum*, we unhesitatingly come to the conclusion that the two are identical. They are of approximately the same size, each possesses a slightly undulate margin, and each an apex encircled by a ring of precisely similar tubercles. The only possible distinction is in the presence of a slight constriction below the ring of tubercles in *D. robustum*, and we have examined sufficient *Pleurotænia* of this nature to know that such a slight variation is of no use as a specific distinction. Moreover, the nature of the tubercles on the two plants is the same, and they are practically equal in number in the two figures given by Turner (30 in his figure of *D. elatum*, 16 being visible; and 32 in his figure of *D. robustum*, 17 being visible). In his text, Turner states that *D. elatum* possesses 35–40 tubercles and *D. robustum* 30–34 tubercles, but these statements are not borne out by his figures.

Turner describes his two plants as having a smooth cell-wall, but we have never yet seen a *Pleurotænium* of this class without a finely scrobiculated cell-wall.

Var. CONJUNCTUM, nob. *Docidium conjunctum*, W. B. Turn. in K. Sv. Akad. Handl. xxv. 1893, no. 5, p. 32, t. 4. fig. 6. Var. minor, marginibus lateralibus cellularum plus undulatis.

Long. circ. 420 μ; lat. bas. et apic. 26 μ (*Turner*).

Hab. Bengal.

—— Forma DUPLO-MAJOR. Long. 682–900 μ; lat. bas. semicell. 54–69 μ; lat. apic. 49–62 μ. (Pl. **18**. figs. 29–32.)

Hab. Paddyfield between Kosgoda and Urahaighasmahendai, Ceylon.

The form seen from Ceylon is about double the size of the plant described as *Docidium conjunctum*, W. B. Turn. It only differs from *Pleurotænium elatum*, Borge, in its rather more undulate lateral margins, and seems to be a form connecting var. *conjunctum* with typical *P. elatum*.

It is highly probable that *Docidium maculatum*, W. B. Turn., and *D. cristatum*, W. B. Turn., are both forms of *Pleurotænium elatum*, as they seem to us to possess no distinctive characters, even the number and nature of the tubercles being the same in each of those "species" as in *P. elatum*.

94. PLEUROTÆNIUM HYPOCYMATIUM, West & G. S. West, in Trans. Linn. Soc., ser. 2, Bot. vol. v. 1896, p. 234, t. 13. fig. 1.

Var. ANGUSTUM, var. n. (Pl. **19**. figs. 3, 4.) Var. minor, semicellulis angustioribus, inflatione basali prominentiore, lateribus superioribus rectis parallelis, undulis prope basin solum.

Long. 321–334 μ; lat. ad bas. semicell. 12–12·5 μ; lat. ad apic. 8·5 μ.

Hab. Padddfields, Heneratgodha.

95. PLEUROTÆNIUM INDICUM, Lund. in Nov. Act. Sci. Upsala, ser. 3, viii. 1871, p. 90. *Docidium indicum*, Grun. 'Diatom. u. Desmid. Insel Banka,' in Rabenhorst's Beiträge zur Kenntniss und Verbreit. Alg. Leipzig, 1865, Heft 2, p. 13, t. 2. fig. 18.

Long. 768 μ; lat. ad bas. semicell. 44 μ; lat. apic. semicell. 25 μ.

Hab. In small pond, Peradeniya.

Forma minor, cellulis paullo angustioribus. Long. 577 μ; lat. ad bas. semicell. 23 μ; lat. apic. semicell. 13·5 μ.

Hab. In artificial tank, Peradeniya.

Var. CRASSIUS, Lagerh. in Botaniska Notiser, 1886, p. 199.

Long. 462 μ; lat. ad bas. semicell. 46 μ; lat. apic. semicell. 28 μ.

Hab. With the typical form, Peradeniya.

96. PLEUROTÆNIUM EHRENBERGII, De Bary, Conj. 1858, p. 75. *Docidium Ehrenbergii,* Bréb. 1844; Ralfs, Brit. Desm. p. 157, t. 26. fig. 4.

Hab. Paddyfields, Heneratgodha. Paddyfield between Kosgoda and Urahaighasmahendai.

Var. UNDULATUM, Schaarschm. in Magyar. Tudom. Akad. math. és Termész. Közlemények, vol. xviii. 1882, p. 278, t. 1. fig. 21.

Long. 345 μ; lat. ad bas. semicell. 22 μ; lat. apic. semicell. 14 μ. (Pl. **18.** fig. 28.)

Hab. In artificial tank, Peradeniya.

The form observed certainly belongs to *P. Ehrenbergii,* and the lateral margins are gently undulate from base to apex; but, although it is of the normal size of a specimen of *P. Ehrenbergii,* it is only about half the size of the plant described by Schaarschmidt as *P. Ehrenbergii,* var. *undulatum.* It is quite probable that the plant described and figured by Schaarschmidt does not belong to *P. Ehrenbergii.*

Var. BORGEI, var. n. (*Pleurotænium basiundatum,* West & G. S. West, forma diametro 17–19-plo longior, apicibus attenuatis, Borge, in Bih. till K. Sv. Vet.-Akad. Handl. 1896, xxii. Afd. 3, no. 9, p. 26, t. 3. fig. 46.) Var. semicellulis paullo angustioribus, undulis parvis circ. 4 supra inflationem basalem.

Long. 368 μ; lat. ad bas. semicell. 19 μ; lat. apic. semicell. 11·5 μ. (Pl. **18.** fig. 27.)

Hab. Paddyfield between Kosgoda and Urahaighasmahendai.

This plant bears little resemblance to *P. basiundatum,* West & G. S. West.

97. PLEUROTÆNIUM MAXIMUM, Lund. in Nov. Act. Soc. Sci. Upsala, ser. 3, viii. 1871, p. 89. *Docidium maximum,* Reinsch, in Abhandl. Senckenb. naturforsch. Gesellsch. vi. 1867, p. 140, t. 27. figs. 1–2; in Abhandl. naturhist. Gesellsch. zu Nürnberg, iii. 1866, p. 184, t. 17. fig. 4. *Pleurotænium Archerii,* Delponte, in Mem. Accad. Sci. Torino, ser. 2, xxx. 1877, p. 128, t. 19. figs. 12–16.

Long. 568 μ; lat. ad bas. semicell. 42 μ; lat. ad med. semicell. 32–33 μ; lat. ad apic. semicell. 27 μ.

Hab. Pond, Victoria Park, Colombo.

We fail to see any difference between *P. maximum* and *P. Archerii.* Both so-called "species" are of about the same size and both have the same outward form. *Pleurotænium maximum* has one moderately large inflation at the base of the semicells, and *P. Archerii* may have one or two. But we have already shown (Journ. Bot. 1897, p. 80) that *P. maximum* may also possess one or two (or even three) basal inflations, so that this character is useless. Moreover, the relative size of the basal inflation of *P. maximum* is very variable, and certainly includes every condition exhibited by Delponte's *P. Archerii.*

Var. PHÆODERMUM, nob. *Pleurotænium phæodermum,* Schaarschm. in Magyar Tudom. Akad. math. és Természettud. Közlemények, xviii. 1883, p. 278, t. 1. fig. 22. *P. Archerii,* Delponte, var. *triannulatum,* Schaarschm. *l. c.* fig. 23. *P. Archerii,* Gutw. in Kom. fizyogr. Akad. Umiej. Krakow, xxx. 1894, t. 3. fig. 14. Var. semicellulis paullo inflatis, distincte attenuatis apicem versus, supra inflationem basalem majorem undulis parvis 2–4; membrana scrobiculato-punctata, achroa, lutea vel brunnea.

Long. 626–646 μ; lat. ad bas. semicell. 37–48 μ; lat. ad med. semicell. 32·5–38·5 μ; lat. apic. semicell. 21–22 μ.

Hab. Paddyfield between Kosgoda and Urahaighasmahendai. In artificial tank, Peradeniya.

The two plants described and figured by Schaarschmidt as *P. phæodermum* and *P. Archerii,* var. *triannulatum,* are undoubtedly representatives of the same species, and we think both fall under *P. maximum* as a variety, which we propose to name var. *phæodermum.* The number of small undulations above the large basal one varies from about two to four. The cell-wall is scrobiculate-punctate as in typical *P. maximum.*

The name "*phæodermum*" was applied by Schaarschmidt to a form with a brown cell-wall, and although specimens are more frequently met with which possess a colourless cell-wall, Schaarschmidt's name must be retained.

Genus TRIPLOCERAS, Bail.

98. TRIPLOCERAS GRACILE, Bail. 1851; Nordst. in K. Sv. Vet.-Akad. Handl. xxii. no. 8, p. 64, t. 7. fig. 12. *Docidium gracile,* Wittr. in Nov. Act. Soc. Sci. Upsala, ser. 3, vol. vii. 1869, pt. 21, t. 1. fig. 10.

Long. 211–332 μ; lat. 25–28 μ.

Hab. Paddyfields, Heneratgodha.

Genus TETMEMORUS, Ralfs.

99. TETMEMORUS GRANULATUS, Ralfs, 1844; Brit. Desm. 1848, p. 147, t. 24. fig. 2, t. 33. fig. 1. *Closterium granulatum,* Bréb. 1839.

Hab. Paddyfields, Heneratgodha. Pool in glen by roadside, near Bandarawella altit. 4000–5000 ft.).

Genus Euastrum, Ehrenb.

100. Euastrum Didelta, Ralfs, 1844; Brit. Desm. 1848, p. 84, t. xiv. fig. 1.

Hab. Paddyfields, Heneratgodha.

101. Euastrum dideltoides, sp. n. (Pl. 19. fig. 12.) *E. quadriceps*, Nordst., forma *dideltoides*, Racib. in Rozpraw. Wydz. matem.-prz. Akad. Umiej. Krakow, tom. xxiv. p. 379, t. 2. fig. 31. *E.* mediocre, 2–2⅕-plo longius quam latum, profundissime constrictum, sinu angusto-lineari; semicellulæ pyramidato-triangulares, angulis basalibus subrectangularibus, lateribus leviter concavis cum undulo lato singulo supra et prope angulos basales; lobo polari producto truncato, leviter dilatato cum angulis rotundatis, in medio apicis incisura subprofunda lineari; tumore singulo supra isthmum, tumore singulo intra angulum basalem utrinque, in centro semicellularum tumoribus parvis binis transverse dispositis et scrobiculis magnis binis verticaliter dispositis; a vertice visæ late ellipticæ, lateribus subtriundulatis, lobo polari globoso-elliptico in medio constricto; membrana minute punctata.

Long. 127–170 μ; lat. 58–82 μ; lat. lob. polar. 24–28 μ; lat. isthm. 16–25 μ; crass. 38 μ.

Hab. Paddyfield between Kosgoda and Urahaighasmahendai.

The plant we found from Ceylon was undoubtedly identical with that described from Australia by Raciborski as *E. quadriceps* forma *dideltoides*. Raciborski does not describe nor figure the vertical view of the plant in question, otherwise he would have observed that it could not possibly belong to *E. quadriceps*, Nordst.

E. dideltoides differs from *E. quadriceps* in being more elongate, in the different arrangement of the protuberances, and the presence of two very large scrobiculations. Moreover, the vertical view is quite different, being broadly elliptical with undulate margins (not rotundo-quadrate as in *E. quadriceps*); also, the polar lobe when viewed from above is subglobose or very broadly elliptical, whereas that of *E. quadriceps* is subquadrate with concave sides.

E. dideltoides should also be compared with *E. Didelta*, Ralfs, and *E. ansatum*, Ehrenb., particularly the latter species, of which it is a close ally.

102. Euastrum ansatum, Ehrenb. in Akad. Wissenschaft. Berlin, 1832, p. 82; Infus. 1838, p. 162, t. 12. fig. vi. 2; Ralfs, Brit. Desm. p. 85, t. 14. fig. 2.

Hab. In stream, Victoria Park, Colombo. Paddyfield between Kosgoda and Urahaighasmahendai. Paddyfields, Heneratgodha.

103. Euastrum gnathophorum, West & G. S. West, in Journ. Linn. Soc., Bot. xxxiii. 1897, p. 160, t. 9. figs. 3, 4.

Long. 65 μ; lat. 31 μ; lat. apic. 18 μ; lat. isthm. 9·5 μ.

Hab. Paddyfields, Heneratgodha. Paddyfield between Kosgoda and Urahaighasmahendai.

104. **Euastrum sinuosum**, Lenorm. in Ralfs, Brit. Desm. p. 85, t. 13. figs. 5 *a*, *b*, *d*.

Hab. In stream, Victoria Park, Colombo. Paddyfield between Kosgoda and Ura haighasmahendai.

Var. **reductum**, West & G. S. West, in Journ. Bot. xxxv. 1897, p. 83; Journ. Linn. Soc., Bot. xxxiii. 1897, p. 160, t. 8. fig. 17.

Hab. Muddy bottom of pool at foot of Hakgala Rock (altit. 6000 ft.).

Var. **Subjenneri**, var. n. (Pl. 19. fig. 17.) Var. minor, tumoribus uniformibus 11 in semicellula unaquaque.

Long. 54 μ; lat. 30 μ; lat. lob. polar. 15 μ; lat. isthm. 9 μ.

Hab. Paddyfields, Heneratgodha.

The eleven protuberances are arranged in the following manner:—There is a circle of six round a central one, and two within the undulations of each lateral margin. It is rather remarkable that this variety possesses the same number of protuberances as *E. Jenneri*, Arch., but the outward form of *E. sinuosum*.

Var. **ceylanicum**, var. n. (Pl. 19. fig. 16.) Var. lobo polari majore elongato et rotundo-dilatato, cum scrobiculis magnis profundissimis binis (verticaliter dispositis) in centro semicellularum.

Long. 76 μ; lat. 32 μ; lat. lob. polar. 19 μ; lat. isthm. 3 μ; crass. 23 μ.

Hab. Paddyfields, Heneratgodha.

In both these varieties there is a small but prominent scrobiculation in the middle of each protuberance.

105. **Euastrum longicolle**, Nordst. in K. Sv. Vet.-Akad. Handl. xxii. no. 8, 1888, p. 33, t. 3. fig. 5.

Var. **capitatum**, var. n. (Pl. 19. fig. 24.) Var. angulis basalibus semicellularum incrassatis et lateribus inferioribus divergentibus, lateribus superioribus plus concavis, lobo polari late dilatato (capitato); scrobiculis distinctis ad lobum polarem et intra angulos laterales; tumoribus et scrobiculo magno ut in forma typica.

Long. 87 μ; lat. 38 μ; lat. lob. polar. 23–26 μ; lat. isthm. 10 μ.

Hab. Paddyfields, Heneratgodha.

106. **Euastrum intermedium**, Cleve, in Öfvers. Sv. Vet.-Akad. Förh. 1863, no. 10, p. 484, t. 4. fig. 1; Lund. in Act. R. Soc. Scient. Upsala, ser. 3, viii. 1871, p. 21, t. 2. fig. 4.

Var. **compactum**, var. n. (Pl. 19. figs. 14, 15.) Var. cellulis diametro circiter duplo longioribus, angulis basalibus rotundo-truncatis, collo lobi polaris latiore, angulis superioribus rotundatis, in centro semicellularum cum scrobiculo magno.

Long. 58–61·5 μ; lat. 31–33 μ; lat. lob. polar. 20 μ; lat. isthm. 9–9·5 μ; crass. 19–22 μ.

Hab. Paddyfields, Heneratgodha.

This variety differs from *Euastrum intermedium*, var. *purum*, West & G. S. West, in its less open sinus, its subtruncate basal angles, and in the stouter neck supporting the polar lobe, as well as in the central scrobiculation.

107. Euastrum subhexalobum, West & G. S. West, in Journ. Linn. Soc., Bot. xxxiii. 1898, t. 16. fig. 7.

Long. 38 μ; lat. 23·5 μ; lat. isthm. 8 μ; crass. 16 μ.

Hab. Paddyfields, Heneratgodha. Paddyfield between Kosgoda and Urahaighasmahendai.

108. Euastrum Freemanii, sp. n. (Pl. **19.** fig. 25.) *E.* mediocre, circiter 1¾-plo longius quam latum, profunde constrictum, sinu lineari externo ampliato; semicellulæ subsemiellipticæ vel oblongo-pyramidatæ, 5-lobæ, incisuris lateralibus profundis similibus et sublate apertis; lobis lateralibus et basalibus similibus subquadratis bilobulatis, incisionibus apertis, lobulis truncatis denticulo singulo ad angulum unumquemque; lobo polari latissime cuneato et truncato, angulis exterioribus dente valido instructis, incisura mediana profunda et subaperta, circa marginem apicalem denticulis circiter 5 utrobique; in centro semicellularum tumore magno et in medio lobi basalis uniuscujusque tumore parvo, juxta et supra tumorem magnum scrobiculis magnis 4 quadrangulariter dispositis; a vertice visæ subellipticæ, polis truncatis et late emarginatis, tumoribus tribus utrobique; a latere visæ anguste pyramidatæ, angulis basalibus prominentibus et rotundatis, lateribus late undulatis, apicibus convexis et tridenticulatis.

Long. 98 μ; lat. 55 μ; lat. lob. polar. (cum spin.) 38 μ; lat. isthm. 13·5 μ; crass. 37 μ.

Hab. Paddyfields, Heneratgodha. Also frequent in paddyfield between Kosgoda and Urahaighasmahendai.

This characteristic species is perhaps nearest to *E. rostratum*, Ralfs, var. *præmorsum*, Nordst., and *E. rostratum*, var. *umbonatum*, West & G. S. West, but differs widely in its lobulation and in its basal protuberances. *E. evolutum*, West & G. S. West, may possibly be said to be of a similar nature, but is less lobulate and has different surface-markings. *E. Freemanii* is also of larger dimensions than the above-mentioned species.

109. Euastrum spinulosum, Delp. in Mem. Accad. Sci. Torino, ser. 2, xxx. 1878, p. 97, t. 6. figs. 17, 18.

Subsp. africanum, Nordst. in Act. Univers. Lund. xvi. 1880, p. 9, t. 1. fig. 16.

Long. 60 μ; lat. 50 μ; lat. isthm. 10 μ. (Pl. **19.** fig. 21.)

Hab. In artificial tank, Peradeniya.

Subsp. inermis, Nordst. *l. c.* fig. 17. *Euastrum inermius*, W. B. Turn. in K. Sv. Vet.-Akad. Handl. xxv. no. 5, 1893, p. 86, t. 10. fig. 51.

Long. 57–60 μ; lat. 50–55 μ; lat. isthm. 11·5–13·5 μ. (Pl. **19.** figs. 22, 23.)

Hab. Paddyfields, Heneratgodha. In artificial tank, Peradeniya.

Var. ceylanicum, var. n. (Pl. **19.** fig. 20.) Var. incisuris lateralibus superioribus angustioribus, granulis magnis confertis et acute conicis; in centro tumore majore cum verrucis angularibus majoribusque.

Long. 67 μ; lat. 55 μ; lat. isthm. 17 μ; crass. 28 μ.

Hab. Pool in glen by roadside, near Bandarawella (altit. 4000–5000 ft.). Paddyfield between Kosgoda and Urahaighasmahendai.

This variety differs from *E. spinulosum*, subsp. *africanum*, in the narrower lateral incisions, the larger polar lobe, and in the much stronger and more acute granules.

110. EUASTRUM EGREGIUM, sp. n. (Pl. 20. fig. 1.) *E.* subparvum, paullo longius quam latum, profundissime constrictum, sinu angusto-lineari extremo subampliato; semicellulæ trilobæ, incisuris lateralibus profundis et apertis; lobis lateralibus trapeziformibus, extrorsum latioribus, lateribus leviter concavis et angulis rotundatis, spinis acutis 2–4 ad angulos et spinis 4–6 irregulariter dispositis intra marginem instructis; lobo polari latissime cuneato, angulis rotundatis, apice retuso, spinis 3–4 ad angulos et spinis 5–6 intra marginem irregulariter dispositis instructo; in centro semicellularum annulo granulorum 8 circa granulum centralem majus; a vertice visæ oblongo-ellipticæ, polis angulari-rotundatis cum spinis 7–8 ad marginem, tumore granulato truncato ad medium utrobique, lobo polari anguste elliptico tumoribus parvis utrobique; semicellulæ a latere visæ constrictæ, parte basali majore late elliptica, parte apicali subcirculari.

Long. 43 μ; lat. 41 μ; lat. lob. polar. 23 μ; lat. isthm. 6 μ; crass. 21 μ.

Hab. Paddyfields, Heneratgodha.

The nearest species to this is *Euastrum spicatum*, W. B. Turn., from which it is distinguished by the closed and very narrow sinus, and by the broad lateral lobes with retuse margins. The lateral incisions on either side of the polar lobe are much deeper and not so open, and the spines, as well as being fewer in number, have quite a different arrangement. The central protuberance is also less granulate than in *E. spicatum*.

111. EUASTRUM SPICATUM, W. B. Turn. in K. Sv. Vet.-Akad. Handl. xxv. no. 5, 1893, p. 87, t. 10. fig. 43.

Forma. Long. 60–73 μ; lat. 52–63 μ; lat. lob. polar. 21–28 μ; lat. isthm. 12·5–16 μ; crass. 29 μ. (Pl. 20. figs. 2, 3.)

Hab. With the preceding species.

The form of this species that we observed differed from that described by Turner in having a closed sinus and stronger less acute spines; moreover, the central protuberance possessed one ring of 7–9 subrectangular granules and a few central ones. On each side of the central protuberance and well within the lateral lobe is a smaller protuberance surmounted by about 3–5 short spines. This feature, which is especially noticeable in vertical view, does not appear to be present in typical *E. spicatum*. We might have placed this plant with equal reason under *E. Hieronymusii*, Schmidle, in Engler's Bot. Jahrbüch. xxvi. 1898, p. 42, t. 2. fig. 35. It seems to us to be a form which is intermediate between *E. spicatum* and *E. Hieronymusii*. It possesses the lateral lobes of the latter, but the slightly retuse polar lobe of the former species. The spines,

although somewhat irregular, are neither truncate nor subemarginate like those figured by Schmidle.

112. EUASTRUM BELLUM, Nordst. in Vidensk. Medd. naturh. Foren. Kjöbenhavn, 1869, p. 218, t. 2. fig. 6.

Var. MADAGASCARIENSE, West & G. S. West, in Trans. Linn. Soc., Bot. ser. 2, v. 1895, p. 49, t. 6. fig. 7.

Forma lobo polari dilatato, denticulis ad basin semicellularum nullis.

Long. 57 μ; lat. 42 μ; lat. lob. polar. 16 μ; lat. isthm. 10 μ; crass. 21 μ. (Pl. 20. fig. 4.)

Hab. With the preceding species.

113. EUASTRUM GEOMETRICUM, sp. n. (Pl. 20. figs. 7, 8.) *E.* parvum, circiter 1½-plo longius quam latum, profunde constrictum, sinu lineari in medio et in fundo ampliato; semicellulæ quadrato-trapeziformes, subtrilobæ, incisuris lateralibus profundis angusto-linearis; lobis lateralibus subquadratis, lateribus inciso-emarginatis, lobulis angulari-rotundatis; lobo polari late oblongo-rectangulari, apice convexo, incisura mediana profunde in fundo ampliata, angulis lateralibus denticulo singulo instructis, denticulis binis ad marginem apicalem utrobique (altero supra marginem altero infra marginem et prope incisuram); tumoribus tribus in serie transversa trans basin semicellularum, tumoribus binis inter incisuras laterales, granula singulo in lobulo laterali unoquoque et in divisione unaquaque lobi polaris; a vertice visæ ellipticæ, tumoribus tribus utrobique; a latere visæ ovatæ, tumore magno ad basin et tumore minore prope apicem utrobique, apicibus tridenticulatis.

Long. 40 μ; lat. 26 μ; lat. isthm. 7·5 μ; crass. 17 μ.

Hab. Paddyfields, Heneratgodha.

114. EUASTRUM PLESIOCORALLOIDES, sp. n. (Pl. 20. figs. 5, 6.) *E.* parvum, 1⅓-plo longius quam latum, profundissime constrictum, sinu angusto-lineari extremo ampliato; semicellulæ pyramidato-quadratæ, trilobæ, incisuris lateralibus profundis et angustis; lobis lateralibus quadrato-trapeziformibus, marginibus lateralibus cum incisura mediana aperta sed non profunda, lobulis emarginatis, angulis lobulorum acutis; lobo polari subelliptico, angulis lateralibus emarginatis, apice leviter elevato cum incisura mediana profunda angusta; tumoribus tribus in serie transversa trans basin semicellularum, tumoribus binis intra lobum polarem, granulis paucis intra marginem loborum lateralum polarumque, scrobiculis paucis in centra semicellularum; a vertice visæ anguste ellipticæ, polis subrotundatis et granulatis, tumoribus tribus utrobique (tumore centrali emarginato).

Long. 34·5–38·5 μ; lat. 25–28 μ; lat. isthm. 5·5–6·5 μ; crass. 16 μ.

Hab. Paddyfields, Heneratgodha.

This species somewhat resembles *E. coralloides*, Josh., var. *trigibberum*, Lagerh. (in Bih. K. Sv. Vet.-Akad. Handl. 1888, xiii. Afd. 3, no. 9, p. 6; *cfr.* also Borge, *l. c.*

1899, xxiv. Afd. 3, no. 12, p. 26, t. 2. fig. 31), but is distinguished by the much deeper and narrower lateral incisions, the different form of the polar lobe, and the different markings on the cell-wall. The protuberances are not granulate, but the middle one of the basal series of three is tripartite, and above the basal protuberances are a number of scrobiculations. Moreover, the apical incision is quite closed (not widely open as in *Euastrum coralloides*), and there are a number of granules within the margins which are quite absent from *E. coralloides* and its var. *trigibberum*.

From *E. geometricum*, sp. n., it is distinguished by its greater breadth, the different form of the sinus, the emarginate lateral lobules, and the elevated apical part of the polar lobe. The median basal tumour and the granules within the margin are also different.

115. EUASTRUM TRUNCATUM, Josh. 'Burm. Desm.,' in Journ. Linn. Soc., Bot. xxi. 1886, p. 639, t. 23. figs. 6, 7.

The following is an amended description of this species:—

E. submediocre, circiter $1\frac{1}{2}$–$1\frac{2}{3}$-plo longius quam latum, profundissime constrictum, sinu angusto-lineari extremo subampliato; semicellulæ trilobæ, incisuris lateralibus profundis angusto-linearis; lobis lateralibus subtrapeziformibus, angulis subrotundatis vel sæpe truncato-emarginatis, lateribus plerumque subretusis (nonnunquam subundulatis); lobo polari rectangulari-trapeziformi, lateribus leviter retusis vel subrectis, apice late retuso; tumore magno in lobo laterali unoquoque, tumore magno in centro et tumore parvo intra marginem lateralem unumquemque lobi polaris, scrobiculo maximo in centro semicellularum; a vertice visæ suboblongæ, polis rotundatis, tumoribus magnis binis subdistantibus utrobique; lobo polari a vertice viso oblongo-elliptico, polis subtruncatis, tumoribus tribus utrobique; a latere visæ ovatæ, tumore magno prope basin et tumore minore apicem versus utrobique, apice angulari-rotundato.

Long. 46–50(–65 *Josh.*) μ; lat. 29–33(–37 *Josh.*) μ; lat. lob. polar. 23–26 μ; lat. isthm. 8·5–9(–16! *Josh.*) μ; crass. 22 μ. (Pl. 20. figs. 9, 10.)

Hab. Paddyfields, Heneratgodha. Paddyfield between Kosgoda and Urahaighasmahendai.

We feel convinced that the plant we have described above as *E. truncatum*, Joshua, is precisely the same as the plant Joshua examined from Burmah. The resemblance between our specimens and his figure of *E. truncatum* is greater than the resemblance between the actual specimens and Joshua's figures of many of his species. Evidence that our plant is the same as *E. truncatum* is also sustained by the fact that many other of Joshua's species were found along with it, and all of them differed considerably in detail from the inaccurate illustrations given by that observer. Joshua, in his description (*l. c.* p. 639), mentions the two large protuberances near the base of the semicells, one being situated in each lateral lobe, but fails to mention the protuberances of the polar lobe and the large scrobiculation in the centre of the semicells.

E. trifolium, Cohn ('Desm. Bong.,' Festschrift natur. Ges. zu Halle, 1879, p 11, t. 11. fig. 13), is undoubtedly the nearest species to *E. truncatum*, possessing three well-marked lobes to each semicell, each lobe having a large protuberance in the centre; the form of the lobes and the absence of the large scrobiculation at once distinguish it, however, from *Euastrum truncatum*.

Quite recently, Schmidle (in Engler's Bot. Jahrbüch. xxvi. Heft 1, 1898, p. 46, t. 2. fig. 37) has described *E. trifolium*, var. *concavum*; but, as this variety possesses a retuse polar lobe and also a central scrobiculation, it seems to us nearer to *E. truncatum*, Josh.

Also, the "*Micrasterias* sp." mentioned and figured by Borge (in Bih. K. Sv. Vet.-Akad. Handl. xxii. Afd. 3, no. 9, p. 11, t. 4. fig. 62) is most probably a close relative, if not a variety, of *E. truncatum*, but lack of detail prevents us from arriving at a definite conclusion.

116. EUASTRUM ABRUPTUM, Nordst. in Vidensk. Medd. naturh. Foren. Kjöbenhavn, 1869, nos. 14–15, p. 217, t. 2. fig. 3.

Hab. Paddyfields, Heneratgodha. Paddyfield between Kosgoda and Urahaighasmahendai.

117. EUASTRUM PULCHERRIMUM, sp. n. (Pl. 20. fig. 11.) *E.* submediocre, circiter 1⅓-plo longius quam latum, profundissime constrictum, sinu angusto-lineari extremo ampliato; semicellulæ truncato-pyramidatæ, trilobæ, incisuris lateralibus apertis et rotundatis; lobis lateralibus semiellipticis, spinis brevibus (vel denticulatis) validis ad marginem et spina singula intra marginem superiorem, in centro juxta sinum verruca emarginata magna ornatis; lobo polari maximo transverse oblongo-rectangulari, angulis inferioribus mamillatis et bidenticulatis, lateribus subconcavis verruca emarginata intra marginem, angulis superioribus dente majore instructis, apicibus truncatis et levissime convexis incisura mediana profundissime et subaperta, verruca emarginata magna utrobique juxta incisuram medianam; in centro semicellularum tumore magno annulo granulorum 7 fimbriato; a vertice visæ oblongo-ellipticæ, tumore trigranulato utrobique, polis emarginatis verruca emarginata utrobique; a latere visæ subovatæ, ad basin tumore trigranulato et apicem versus verruca emarginata utrobique.

Long. 59 μ; lat. 36 μ; lat. lob. polar. 29 μ; lat. isthm. 7·5 μ; crass. 24 μ.

Hab. Paddyfields, Heneratgodha. Paddyfield between Kosgoda and Urahaighasmahendai.

Perhaps the nearest species to this is *E. flammeum*, Joshua, but it differs entirely in the form of its polar lobe, in its ornamentation, and in its vertical and lateral views.

Compare also with *E. evolutum*, var. *integrius*, West & G. S. West.

118. EUASTRUM PERSONATUM, West & G. S. West, in Trans. Linn. Soc., Bot. ser. 2, v. 1895, p. 52, t. 6. fig. 19.

Long. 41 μ; lat. 30 μ; lat. lob. polar. 21 μ; lat. isthm. 6 μ; crass. 18 μ.

Hab. In artificial tank, Peradeniya.

119. Euastrum fissum, sp. n. (Pl. 20. figs. 17, 18.) *E.* parvum, circiter duplo longius quam latum, profundissime constrictum, sinu angusto-lineari extremo ampliato; semicellulæ semiellipticæ vel pyramidato-ovatæ, angulis basalibus subrectangularibus (lateribus extrorsum divergentibus), lateribus in medio (circ.) retuso-emarginatis et valde incrassatis, supra partem retusam laterum cum dente parvo obtuso, apicibus rotundo-truncatis in parte mediana incisura profundissima angusto-lineari, cum granulo intra marginem ad medium utrobique, tumore basali parvo emarginato supra isthmum; a latere visæ angusto-ovatæ, cum tumore emarginato-truncato prope basin et granulo supra tumorem utrobique; a vertice visæ ellipticæ, tumore parvo emarginato ad medium utrobique, polis rotundatis.

Long. 34·5–41 μ; lat. 19–22 μ; lat. isthm. 3–4 μ; crass. 13·5 μ.

Hab. Paddyfields, Heneratgodha.

At first sight it may appear to be undesirable to create another specific name for an *Euastrum* of the nature of *E. elegans*, *E. pseudelegans*, &c., but on further consideration we think it solves a difficulty. Numerous specimens were examined and all possessed exactly the same structural features, and rather than refer the plant to a badly described form which may be itself merely a variety of some other "*elegans*-like" *Euastrum*, we think it much better to give it a name by which it can always be recognized. The plant possesses certain characters, such as the very deep polar incision and the emarginate *thickened* notch at the sides, which at once distinguish it from *E. elegans* and its varieties, not to mention other peculiarities of less importance.

Almost the nearest approach we can find to *E. fissum* is a figure given by Turner (in K. Sv. Vet.-Akad. Handl. xxv. no. 5, t. 10. fig. 37) of *E. subspinosum*, W. B. Turn., var. *tumida*, W. B. Turn.; but *E. subspinosum*, W. B. Turn., 1893, *E. annulatum*, W. B. Turn., 1893, and *E. incurvatum*, W. B. Turn., 1893, are most certainly referable to the same species as *E. pseudelegans*, W. B. Turn., 1885! And, perhaps, *E. pseudelegans* would be more correctly placed as a variety of *E. elegans* with rounded basal angles.

It may also be compared with *E. bilobum*, Lütkem. (in Verhandl. d. k. k. zool.-bot. Ges. Wien, xlii. 1892, p. 561, t. 9. fig. 13).

120. Euastrum rostratum, Ralfs, 1844; Brit. Desm. 1848, p. 88, t. 14. fig. 6.

Forma cellulis paullo latioribus, lobulis superioribus loborum lateralium emarginatis.

Long. 47 μ; lat. 35 μ; lat. lob. polar. cum spin. 22–23 μ; lat. isthm. 6 μ. (Pl. 20. fig. 13.)

Hab. Paddyfields, Heneratgodha.

Forma cellulis paullo latioribus, cum granulo magno infra basin incisuræ apicalis utrobique (ut in var. *umbonato*).

Long. 47 μ; lat. 31 μ; lat. lob. polar. cum spin. 21–22·5 μ; lat. isthm. 7·5 μ; crass. 20·5 μ. (Pl. 20. fig. 12.)

Hab. With the preceding form.

Both these forms are relatively wider than *E. rostratum*, and somewhat intermediate between it and the var. *umbonatum*, West & G. S. West. Schmidle (in Flora, lxxxii. 1896, Heft 3, p. 310) places *E. rostratum*, var. *umbonatum*, as a species (*Euastrum* *umbonatum*), but we are unable to see any reason for this, as the outward form and central elevation are exactly similar to those of typical *E. rostratum*, Ralfs.

121. EUASTRUM LOBULATUM, Bréb. in Mém. Soc. Sci. Nat. Cherbourg, iv. 1856, p. 124, t. 1. fig. 4; West & G. S. West, in Journ. Bot. xxxviii. 1900, p. 290. *E. erosum*, Lund., var. *notabile*, West, in Journ. Roy. Micr. Soc. 1892, p. 723, t. 9. fig. 17.

Var. TROPICUM, var. n. (Pl. 19. fig. 13.) Var. angulis basalibus subrectangularibus (lateribus angulorum basalium subdivergentibus) leviter retusis, in centro semicellularum cum tumore prominenti quadrigranulato.

Long. 30 μ; lat. 18 μ; lat. apic. semicell. 11 μ; lat. isthm. 4·5 μ; crass. 14 μ.

Hab. With the preceding species.

This is very similar to a form figured by Schmidle as *E. elegans* forma (in Engler's Bot. Jahrbüch. xxvi. 1898, t. 2. fig. 36).

122. EUASTRUM DENTICULATUM, F. Gay, in Bull. Soc. Bot. France, xxxi. 1884, p. 335. *E. binale*, var. *denticulatum*, Kirchn. in Cohn's Kryptog. Flor. Schlesien, 1878, p. 159.

Hab. Stream, Victoria Park, Colombo. In artificial tank, Peradeniya. Pool in glen by roadside, near Bandarawella (altit. 4000–5000 ft.). Paddyfield between Kosgoda and Urahaighasmadendai.

Forma cellulis paullo latioribus, angulis basalibus semicellularum rectangularibus.

Long. 35 μ; lat. 27 μ; lat. isthm. 5 μ. (Pl. 20. fig. 16.)

Hab. Paddyfield between Kosgoda and Urahaighasmahendai.

123. EUASTRUM BASICHONDRUM, sp. n. (Pl. 20. figs. 14, 15.) *E.* minutum, $1\frac{1}{3}$-plo longius quam latum, profunde constrictum, sinu angusto-lineari extremo ampliato; semicellulæ oblongo-hexagonæ, angulis inferioribus subrectangularibus, lateribus inferioribus subrectis et subdivergentibus, lateribus superioribus levissime concavis et incrassatis, apicibus latis leviter retuso-emarginatis, granulo magno supra et juxta isthmum, granulo infra et juxta medium apicis, et scrobiculo singulo intra marginem ad medium lateris superioris uniuscujusque instructæ; a latere visæ truncato-ovatæ, ad basin utrobique granulo magno instructæ; a vertice visæ ellipticæ.

Long. 21–24 μ; lat. 15–18 μ; lat. apic. 10·5–12 μ; lat. isthm. 3·7–4·8 μ; crass. 9·7 μ.

Hab. Paddyfields, Heneratgodha.

The form of the cell, the prominent granules above the isthmus, and those below the middle of the apex of each semicell are characteristic. The peculiarly thickened upper portions of the lateral margins, and the scrobiculations within them, are also features which enable this plant to be distinguished from other small species of the genus. *E. validum*, West & G. S. West, is the only other small species of *Euastrum* which possesses a granule on each side of the isthmus. It may also be compared with *E. crassangulatum*, Börgesen.

124. EUASTRUM BINALE, Ehrenb. in Bericht Verh. Akad. Wissensch. Berlin, 1840, pp. 208–9; Ralfs, Brit. Desm. 1848, p. 90, t. 14. fig. 8. *Heterocarpella binalis*,

Turp. 1820. *Cosmarium Aitchisonii*, as figured by Turner in K. Sv. Vet.-Akad. Handl. 1893, xxv. no. 5, t. 8. fig. 54 *a*, *b* (*a* is oblique).

Hab. Among *Spirogyra* sp. in fast-running stream, Peradeniya. In stream and in ponds, Victoria Park, Colombo. Paddyfield between Kosgoda and Urahaighasmahendai.

Forma HIANS, West, in Journ. Linn. Soc., Bot. xxix. 1892, p. 140, t. 20. fig. 14.

Hab. Paddyfield between Kosgoda and Urahaighasmahendai.

125. EUASTRUM INSULARE, Roy, in Scot. Naturalist, vii. 1883, p. 40. *E. binale*, var. *insulare*, Wittr. in Bih. till K. Sv. Vet.-Akad. Handl. i. no. 1, p. 49, t. 4. fig. 7.

Long. 17·5 μ; lat. 11·5 μ; lat. isthm. 3·3 μ.

Hab. Paddyfields, Heneratgodha. Paddyfield between Kosgoda and Urahaighasmahendai. Stream, Victoria Park, Colombo.

126. EUASTRUM VALIDUM, West & G. S. West, in Trans. Linn. Soc., Bot. ser. 2, v. 1896, p. 245, t. 14. figs. 32, 33.

Long. 26·5 μ; lat. 19 μ; lat. apic. 13·5 μ; lat. isthm. 4·4 μ; crass. 10 μ.

Hab. Paddyfields, Heneratgodha.

A little smaller, otherwise exactly like the American forms of the species.

127. EUASTRUM LIGATUM, sp. n. (Pl. **19.** figs. 18, 19.) *E.* perminutum, subduplo longius quam latum, profundissime constrictum, sinu acuto et aperto; semicellulæ truncato-pyramidatæ, lateribus profunde retusis, angulis inferioribus et superioribus acute rotundatis, apicibus latis convexis et in medio retuso-emarginatis; a latere visæ truncato-ovatæ, sub apice constrictæ; a vertice visæ ellipticæ; membrana glabra.

Long. 14·5–15 μ; lat. 9·4–9·7 μ; lat. apic. 7·2–7·7 μ; lat. isthm. 2·7–3·2 μ; crass. 6 μ.

Hab. Paddyfields, Heneratgodha.

At first sight this resembles *Spondylosium pulchellum*, Arch., and especially the var. *austriacum*, Lütkem. (in Verhandl. d. k. k. zool.-bot. Ges. Wien, 1892, xlii. p. 539, t. 8. fig. 1), but on closer examination the difference is at once evident. *E. ligatum* is relatively narrower, the constriction is very much deeper, the sinus is more open, the angles are *acutely* rounded, and the apex is convex and slightly emarginate in the middle. The apices of the cells of *Spondylosium pulchellum* are absolutely straight, as it is by the close application of these flat ends that the cells are joined into long filaments. *E. ligatum* does not occur in a filamentous state, and the side view of the semicells shows a marked constriction below the apex, which is not present in *Spondylosium pulchellum*.

Genus MICRASTERIAS, Ag.

128. MICRASTERIAS PINNATIFIDA, Ralfs, Brit. Desm. 1848, p. 77, t. 10. fig. 3. *Euastrum pinnatifidum*, Kuetz. Sp. Alg. p. 171.

Hab. Paddyfields, Heneratgodha.

129. MICRASTERIAS CRUX-MELITENSIS, Ralfs, Brit. Desm. 1848, p. 73, t. 9. fig. 3. *Euastrum Crux-Melitensis*, Ehrenb.

Hab. With the preceding species.

130. MICRASTERIAS MAHABULESHWARENSIS, Hobson, in Quart. Journ. Micr. Sci. 1863, p. 130; Lundell, in Act. R. Soc. Scient. Upsala, ser. 3, viii. 1871, p. 15, t. 1. fig. 6.

Var. SURCULIFERA, Lagerh. in Bih. till K. Vet.-Akad. Handl. xiii. Afd. 3, no. 9, 1888, p. 5, t. 1. fig. 1.

Long. 128 μ; lat. 128–138 μ; lat. isthm. 20 μ. (Pl. **20.** fig. 20.)

Hab. Paddyfield between Kosgoda and Urahaighasmahendai.

131. MICRASTERIAS ALATA, G. C. Wallich, in Ann. & Mag. Nat. Hist. ser. 3, v. 1860, p. 279, t. 8. fig. 11.

Long. 153 μ; lat. 132–138 μ; lat. isthm. 15 μ.

Hab. Paddyfields, Heneratgodha. Paddyfield between Kosgoda and Urahaighasmahendai.

132. MICRASTERIAS URNIFORMIS, sp. n. (Pl. **20.** fig. 19.) *M.* parva, circiter 1¼-plo longior quam lata, profunde constricta, sinu aperto acutangulo; semicellulæ pyramidato-trapeziformes, cum angulis productis, angulis basalibus lobiformibus truncato-rotundatis cum denticulis 4 instructis, lateribus superioribus valde retusis, angulis superioribus in processus breves truncatos tridenticulatos (vel trispinatos) productis, apicibus convexis; a vertice visæ ellipticæ, polis levissime truncatis et tridenticulatis; membrana minute punctulata.

Long. cum spin. 59·5–61·5 μ; lat. cum spin. 48–50 μ; lat. isthm. 17–18 μ; crass. 21·5 μ.

Hab. Paddyfields, Heneratgodha.

133. MICRASTERIAS FOLIACEA, Bail. in Ralfs, Brit. Desm. p. 210, t. 35. fig. 3; L. N. Johnson, in Bot. Gaz. xix. 1894, p. 56, t. 6. figs. 1–4.

Long. 69–76 μ; lat. 63–70 μ; lat. isthm. 12·5–14·5 μ.

Hab. Paddyfields, Heneratgodha. Paddyfield between Kosgoda and Urahaighasmahendai.

134. MICRASTERIAS DECEMDENTATA, Arch. in Pritch. Infus. ed. 4, 1861, p. 726. *Euastrum decemdentatum*, Naeg. Gatt. einz Alg. 1849, p. 123, t. 6 H. fig. 2.

Long. 60–64 μ; lat. cum spin. 64–71 μ; lat. isthm. 13·5–15 μ.

Hab. Paddyfields, Heneratgodha. Stream, Victoria Park, Colombo.

135. MICRASTERIAS THOMASIANA, Arch. in Proc. Dubl. Nat. Hist. Soc. 1862, p. 72, t. 2. figs. 1–5; Quart. Journ. Micr. Sci. 1862, p. 259, t. 12.

Hab. Paddyfields, Heneratgodha.

Genus XANTHIDIUM, Ehrenb.

136. XANTHIDIUM ACANTHOPHORUM, Nordst. in Act. Univ. Lund. 1880, xvi. p. 11, t. 1. fig. 20; inclus. *X. acanthophorum*, var. *bengalicum*, Lagerh. in Bih. K. Sv. Vet.-Akad. Handl. 1888, xiii. Afd. 3, no. 9, p. 9, t. 1. fig. 7.

Long. sine spin. 40–46 μ, cum spin. 54–57·5 μ; lat. sine spin. 33–39 μ, cum spin. 42–46 μ; lat. isthm. 10–11·5 μ.

Hab. Paddyfields, Heneratgodha. Paddyfield between Kosgoda and Urahaighasmahendai.

The scrobiculated area in the centre of the semicells is very large, and the disposition of the scrobiculations very variable, hardly any two specimens having the same arrangement on the two semicells of the same plant. Thus, the var. *bengalicum*, Lagerh., cannot be considered as a form in any way differing from ordinary typical examples.

137. XANTHIDIUM FREEMANII, sp. n. (Pl. 20. fig. 28.) *X.* submagnum, paullo longius quam latum (sine spinis), subprofunde constrictum, sinu lineari extremo ampliato; semicellulæ depresso-semicirculares, apicibus truncatis rectis, angulis basalibus rotundatis, margine laterali unoquoque serie spinarum acutarum subcurvatarum 9 præditis, et serie spinarum similium 9 intra marginem, apicibus glabris; membrana dense et minute scrobiculata, in centro semicellularum . . . . . ?; a vertice visæ ellipticæ, cum . . . . . . ? . . . utrobique, polis rotundatis spinis 4 instructis.

Long. sine spin. 80 μ, cum spin. 89 μ; lat. sine spin. 73 μ, cum spin. 82 μ; lat. isthm. 34 μ; long. spin. circ. 4·8–5·7 μ.

Hab. Paddyfields, Heneratgodha.

We regret that we cannot give a more complete description of this characteristic *Xanthidium*, which presents very little resemblance to any other species of the genus. The cell-wall was minutely scrobiculate, but the nature of the central tumour could not be made out, neither were the other views obtainable. There are four subparallel series each of nine spines arranged along each lateral margin from the basal angle to the side of the apex.

138. XANTHIDIUM BREVICORNE, W. B. Turn. in K. Sv. Vet.-Akad. Handl. 1893, xxv. no. 5, p. 101, t. 13. fig. 9.

Var. CEYLANICUM, var. n. (Pl. 20. fig. 27.) Var. cellulis profundissime constrictis, isthmo angustiore et sinu apertiore; in centro semicellularum incrassata cum annulo scrobiculorum parvorum 6; spinis longioribus.

Long. (sine spin.) 51 μ; lat. sine spin. 43 μ, cum spin. 49 μ; lat. isthm. 14·5 μ; crass. 24 μ; long. spin. 3·2–3·8 μ.

Hab. With the preceding species.

139. XANTHIDIUM CEYLANICUM, sp. n. (Pl. 20. figs. 24, 25.) *X.* parvum, circiter $1\frac{1}{3}$-plo longius quam latum, profunde constrictum, sinu angusto-lineari extremo ampliato; semicellulæ rotundo-pyramidatæ, angulis basalibus rectangularibus, lateribus convexis serie spinarum 5–6 instructis, spinis multo majoribus apicem versus, apicibus

leviter convexis, membrana supra centrum semicellularum valde incrassata lutea et scrobiculata, ad basin supra isthmum cum granulo magno; a vertice visæ rhomboideo-ellipticæ, polis spinulatis, ad medium utrobique valde incrassatis; a latere visæ subcirculares, seriebus distantibus 2 spinarum verticaliter dispositis et divergentibus apicem versus, granulo singulo utrobique prope isthmum.

Long. sine spin. 29–33 μ, cum spin. 32·5–35 μ; lat. sine spin. 23–25·5 μ; lat. isthm. 6·5–7·5 μ; crass. 17 μ.

Hab. Paddyfields, Heneratgodha. Among Podostemons, Mahawelli Ganga, near Peradeniya.

This species at first sight much resembles *Xanthidium lepidum* (see next species), but differs in its smaller size, its much more irregular spines, which are always large near the apical angles and very small near the basal angles. The spines near the basal angles are disposed irregularly, but become arranged in pairs towards the apex. The scrobiculate thickened area above the centre of the semicells is of quite a different nature from that of *X. lepidum*; seen from the side or apex it possesses several very small protuberances, which are entirely absent from the corresponding area of *X. lepidum*. Another distinguishing feature of *X. ceylanicum* is the large granule at the base of the semicells just above the isthmus. Also, the series of four large granules within the apex of *X. lepidum* are entirely wanting in *X. ceylanicum*.

This species might also be compared with *X. searsolense*, W. B. Turn.

Both *X. ceylanicum* and *X. lepidum* occurred in abundance in the same gathering, and could always be distinguished from one another at a glance.

140. Xanthidium lepidum, sp. n. (Pl. 20. figs. 22, 23.) *X.* subparvum, circiter 1½-plo longius quam latum (sine spinis), profundissime constrictum, sinu angusto-lineari extremo valde ampliato; semicellulæ rotundato-pyramidatæ, lateribus convexis serie spinarum parvarum 5–6 instructis (nonnunquam cum spinis parvis 2–3 intra angulum inferiorem), apicibus leviter convexis serie granulorum depressorum magnorum 4 infra et juxta marginem instructis, supra centrum membrana incrassata scrobiculis 8–12 ornata; a vertice visæ truncato-ellipticæ, in medio utrobique incrassatæ, apicibus truncatis spinis duobus instructis; a latere visæ truncato-ovatæ, seriebus subparallelis distantibusque 2 spinarum verticaliter dispositis, granulo singulo ad angulum unumquemque superiorem.

Long. sine spin. 36–43 μ; lat. sine spin. 26·5–28 μ, cum spin. 32–36·5 μ; lat. isthm. 7–7·5 μ; crass. 17·5 μ; long. spin. 1·8–3·8 μ.

Hab. Paddyfields, Heneratgodha.

This species approaches *X. searsolense*, W. B. Turn. (in K. Sv. Vet.-Akad. Handl. 1893, xxv. no. 5, p. 101, t. 13. fig. 8), but is somewhat larger in size, has a series of four flattened granules just within the apices instead of two emarginate processes, and possesses a thickened scrobiculated area just above the centre of the semicells, which is entirely absent from *X. searsolense*.

We find the outward form of *X. lepidum* somewhat variable, and it possesses either 5 or 6 pairs of spines along each lateral margin. It is usually the smaller forms which

have only five pairs on each side, and they have in addition a few scattered smaller spines within the basal angles.

141. Xanthidium quadridentatum, sp. n. (Pl. **20.** fig. 21.) *X.* submediocre, circiter $1\frac{1}{5}$-plo longius quam latum (sine spinis), profunde constrictum, sinu lineari extremo valde ampliato; semicellulæ pyramidato-semicirculares, angulis inferioribus subrotundatis dente parvo instructis, lateribus cum serie spinarum 4 (spinis gradatim majoribus apicem versus), apicibus latis truncato-convexis spina majore valida ad angulum superiorem unumquemque, serie granulorum depressorum magnorum 6 intra et juxta marginem apicis, in centro membrana incrassata luteo-brunnea cum scrobiculis 8–9; a latere visæ subcirculares, seriebus divergentibus 2 spinarum et granulorum apicem versus, in medio apicis cum spina valida, lateribus incrassatis; a vertice visæ late ellipticæ, serie spinarum et granulorum intra marginem lateralem unumquemque, polis rotundatis spinulatis, in medio utrinque incrassatis.

Long. sine spin. 46 μ, cum spin. 51 μ; lat. (s. spin.) 38 μ; lat. isthm. 10 μ; crass. 26 μ.

Hab. Paddyfields, Heneratgodha.

This species somewhat resembles *X. lepidum* (p. 159) and *X. ceylanicum* (p. 158), but can be readily distinguished from either. It differs from *X. lepidum* in its general form and proportion in all views, in the arrangement, number, and form of its spines, in the large single spines at the superior angles, and in the six flattened granules within the apex. *X. lepidum* possesses only four flattened granules within the apex, and it agrees with *X. quadridentatum* in having these granules arranged in a continuous series with the lateral paired spines. These series are subparallel in *X. lepidum*, but widely divergent in *X. quadridentatum.*

From *X. ceylanicum* it is chiefly distinguished by its larger size and different outward form, by the presence of the six flattened granules within the apex, and by the large single spines at the superior angles. It is also without the large granule present above the isthmus in *X. ceylanicum*, and the central scrobiculated area is relatively much smaller.

Compare also with *X. torquatum*, W. B. Turn. (in K. Sv. Vet.-Akad. Handl. xxv. no. 5, 1893, p. 102, t. 22. fig. 8).

142. Xanthidium variabile, West & G. S. West, in Journ. Bot. xxxviii. 1900, p. 291. *X. Smithii*, Arch., var. *variabile*, Nordst. 1887; in K. Sv. Vet.-Akad. Handl. xxii. no. 8, 1888, p. 44, t. 4. figs. 27–29; West & G. S. West, in Journ. Roy. Micr. Soc. 1896, p. 156, t. 4. fig. 10; G. S. West, in Journ. Linn. Soc., Bot. xxvii. 1899, p. 386, t. 8. figs. 20–22.

Long. (sine spin.) 22 μ; lat. sine spin. 21 μ, cum spin. 23·5 μ; lat. isthm. 6 μ; crass. 15 μ.

Hab. Paddyfield between Kosgoda and Urahaighasmahendai.

143. Xanthidium inconspicuum, sp. n. (Pl. **20.** fig. 26.) *X.* minutissimum, paullo longius quam latum (sine spinis), profunde constrictum, sinu lineari extrorsum leviter aperto; semicellulæ angulari-oblongæ, angulis inferioribus rectangularibus et leviter rotundatis, angulis superioribus truncato-rotundatis, apicibus late truncatis

rectis, spinis divergentibus acutis tribus ad marginem lateralem unumquemque regulariter dispositis, ea infima breviore, in centro granulo instructæ; a vertice visæ oblongo-ellipticæ, spina singula ad polum unumquemque, granulo prominenti singulo ad medium utrobique; a latere visæ globosæ.

Long. sine spin. 9 μ, cum spin. 11·7 μ; lat. sine spin. 7·8 μ, cum spin. 10·5 μ; lat. isthm. 2·1 μ; crass. 5·1 μ.

Hab. Paddyfields, Heneratgodha.

This minute *Xanthidium* is readily distinguished from any other species of the genus. The only plant approaching it is *Arthrodesmus ineptus* (=*Xanthidium ineptum*, W. B. Turn. in K. Sv. Vet.-Akad. Handl. 1893, xxv. no. 5, p. 101, t. 12. fig. 21); but in the latter species the semicells are more elliptic, the spines are irregularly disposed and less divergent, and the semicells are devoid of a central protuberance. This last character shows that Turner was wrong in placing his plant in the genus *Xanthidium*.

144. XANTHIDIUM BENGALICUM, W. B. Turn. in K. Sv. Vet.-Akad. Handl. xxv. no. 5, 1893, p. 100, t. 12. fig. 32.

Long. sine spin. 49 μ, cum spin. 77 μ; lat. sine spin. 48 μ, cum spin. 80 μ; lat. isthm. 13 μ; crass. 26 μ.

Hab. With the preceding species.

145. XANTHIDIUM HASTIFERUM, W. B. Turn. in Journ. Roy. Micr. Soc. 1885, p. 938, t. 15. fig. 20. *X. antilopæum*, Kuetz., var. *angulatum*, Josh. in Journ. Linn. Soc., Bot. xxi. 1886, p. 643, t. 24. fig. 16.

Var. JAVANICUM, W. B. Turn. in K. Sv. Vet.-Akad. Handl. xxv. no. 5, 1893, p. 100. *X. antilopæum*, Kuetz., forma *javanica*, Nordst., 1880.

Long. sine spin. 37 μ, cum spin. 58 μ; lat. sine spin. 36·5–40 μ, cum spin. 73 μ; lat. isthm. 9·5 μ.

Hab. With the preceding species.

In all the specimens examined the spines were very long and delicate, and the sinus was distinctly closed, the latter feature being absent from both the figures of Turner and Nordstedt.

Genus COSMARIUM, Corda.

146. COSMARIUM NYMANNIANUM, Grun. in Rabenh. Flor. Europ. Algar. iii. 1868, p. 166; Lund. in Act. R. Soc. Scient. Upsala, ser. 3, viii. 1871, p. 36, t. 3. fig. 1.

Hab. Paddyfields, Heneratgodha. Paddyfield between Kosgoda and Urahaighasmahendai.

147. COSMARIUM HAMMERI, Reinsch, in Abhandl. naturhistor. Gesellsch. Nürnberg, 1866, p. 111, t. 10. fig. 1. *C. homalodermum*, Nordst. in Öfvers. K. Sv. Vet.-Akad. Förh. 1875, no. 6, p. 18, t. 6. fig. 4.

Forma.

Long. 29–38·5 μ; lat. 21–25 μ; lat. apic. 11·5–17 μ; lat. isthm. 7·5–8·7 μ; crass. 16 μ.

Hab. Pond, Royal Botanical Gardens, Peradeniya. In artificial tank, and also in running water, in the Royal Botanical Gardens, Peradeniya.

148. Cosmarium granatum, Bréb. in Ralfs, Brit. Desm. 1848, p. 96, t. 32. fig. 6.

Hab. Paddyfields, Heneratgodha. In artificial tank, and also in running water, Royal Botanical Gardens, Peradeniya.

149. Cosmarium inæqualipellicum, West & G. S. West, in Trans. Linn. Soc., Bot. ser. 2, v. 1895, p. 54, t. 6. figs. 28, 29.

Hab. Paddyfields, Pandure and Heneratgodha. Paddyfield between Kosgoda and Urahaighasmahendai.

150. Cosmarium pachydermum, Lund. in Act. R. Soc. Scient. Upsala, ser. 3, 1871, p. 39, t. 2. fig. 15.

Var. minus, Nordst. in Act. Univers. Lund. ix. 1873, p. 18, t. 1. fig. 7.

Long. 56–60 μ; lat. 46–48 μ; lat. isthm. 17–19 μ.

Hab. In sluggish stream, Victoria Park, Colombo. Among *Spirogyra* sp. in fast-running stream, Peradeniya. Pond, Royal Botanical Gardens, Peradeniya. Pool in glen by roadside, near Bandarawella (altit. 4000–5000 ft.). In stagnant water of tank, Peradeniya.

151. Cosmarium Lundellii, Delp. in Mem. Accad. Sci. Torino, ser. 2, xxx. 1878, p. 13, t. 7. figs. 62–64. *C. subcirculare,* W. B. Turn. in K. Sv. Vet.-Akad. Handl. xxv. no. 5, 1893, p. 52, t. 8. fig. 3, and t. 9. figs. 27, 37.

Var. corruptum, nob. *C. corruptum,* W. B. Turn. *l. c.* p. 51, t. 8. fig. 2. *C. subcirculare,* var. *rugosum,* W. B. Turn. *l. c.* p. 52, t. 8. fig. 7. *C. rotundum,* W. B. Turn. *l. c.* p. 58, t. 8. fig. 48. Var. minor, sinu non vel paullo aperto; scrobiculis variabilibus, plerumque validioribus prope margines.

Long. 51–59 μ; lat. 48·5–57·5 μ; lat. isthm. 23–37 μ.

Hab. Paddyfields, Heneratgodha. *Distrib.* Bengal; Central India.

The plants named by Turner *C. corruptum, C. subcirculare,* and *C. rotundum* are unquestionably forms of *C. Lundellii,* Delp. We have examined large numbers of *C. Lundellii* and its varieties from many parts of the world, and the nature of the sinus and the arrangement of the punctulations (or minute scrobiculations) on the cell-wall varies greatly.

The var. *corruptum,* nob., differs from typical *C. Lundellii* only in being somewhat smaller, in the sinus being a little more closed, and in the minute scrobiculations generally appearing rather more distinct at the margins. Considering the wide distribution and the immense variability of this plant, we see no character by which Indian forms of it can be separated as species.

152. COSMARIUM MACULATUM, W. B. Turn. in K. Sv. Vet.-Akad. Handl. xxv. no. 5, 1893. p. 49, t. 7. fig. 31, t. 8. fig. 68 (forma). *C. tumescens*, W. B. Turn. *l. c.* p. 49, t. 7. fig. 32. *C. maculatiforme*, Schmidle, 'Alg. Sumatra,' in Hedwigia, xxxiv. 1895. p. 301, t. 4. figs. 3, 4. *C. javanicum*, Nordst., var. *latum*, Lütkem. in Ann. k. k. naturhist. Hofmus. Wien, xv. Heft 2, p. 118. *C.* chromatophoris parietalibus elongatis 6 in semicellula unaquaque, pyrenoidibus in serie singula in chromatophora unaquaque.

Long. 127 μ; lat. 70 μ; lat. isthm. 49 μ; crass. 55 μ.

Hab. Pool in glen by roadside, near Bandarawella (altit. 4000–5000 ft.).

After having examined a number of specimens of the plant from Ceylon we fail to see any distinction whatever between *C. maculatum*, W. B. Turn., and *C. tumescens*, W. B. Turn., from Northern India, and *C. maculatiforme*, Schmidle, from Sumatra. The semicells varied a certain amount in outline, and included forms with a somewhat narrowed apex, such as those figured by Schmidle. Our specimens had a sinus exactly like the one figured by Schmidle for *C. maculatiforme*, but the majority of specimens had slightly broader apices, such as those figured by Turner for his *C. maculatum* and *C. tumescens*; but, although the apices were as broad as those of Turner's *C. maculatum* and *C. tumescens*, they were truncate as in Schmidle's *C. maculatiforme*. The vertical view is broadly elliptical, and the chlorophyll is also arranged in six parietal bands, exactly as described by Schmidle for *C. maculatiforme*. *C. tumescens*, W. B. Turn., is merely a form of *C. maculatum*, with a slightly thicker cell-wall.

153. COSMARIUM PYRAMIDATUM, Bréb. in Ralfs, Brit. Desm. 1848, p. 94, t. 15. figs. 4 *a*, *b*, *c*.

Hab. Paddyfields, Heneratgodha. In artificial tank, Peradeniya.

154. COSMARIUM PSEUDOPYRAMIDATUM, Lund. in Acta R. Soc. Scient. Upsala, ser. 3, viii. 1871, p. 41, t. 2. fig. 18.

Hab. Paddyfields, Heneratgodha. Paddyfield between Kosgoda and Urahaighasmahendai.

155. COSMARIUM VARIOLATUM, Lund. *l. c.* p. 41, t. 2. fig. 19.

Long. 30·5 μ; lat. 18 μ; lat. isthm. 6 μ.

Hab. Stream, Victoria Park, Colombo.

156. COSMARIUM ZONATUM, Lund. *l. c.* p. 50, t. 3. fig. 18.

Long. 51 μ; lat. 26 μ; lat. isthm. 11 μ; crass. 20 μ.

Hab. Paddyfields, Heneratgodha. Paddyfield between Kosgoda and Urahaighasmahendai.

The specimens were very similar to the Swedish ones, but were proportionately a little broader, with the lower two-thirds of the semicells more inflated; the zones of punctulations were very similar, but the one across the broadest part of the semicells was a single series.

157. COSMARIUM OBSOLETUM, Reinsch, in Abhandl. naturhist. Gesellsch. Nürnberg, iii. 1866, p. 110, t. 9. fig. 5.

Long. 41–67 μ; lat. 50–76 μ; lat. isthm. 22–31 μ.

Hab. Paddyfields, Heneratgodha. Paddyfield between Kosgoda and Urahaighasmahendai.

The specimens were exactly like those from Singapore (*cf.* Journ. Linn. Soc., Bot. xxxiii. 1897, p. 164).

158. COSMARIUM PSEUDOSCENEDESMUS, sp. n. (Pl. 20. fig. 34.) *C.* subparvum, circiter 1¾-plo latius quam longum, profundissime constrictum, sinu angusto-lineari extremo leviter ampliato; semicellulæ depresso-semiellipticæ, angulis basalibus rotundatis, apicibus subtruncatis; a vertice visæ anguste ellipticæ; a latere visæ circulares; membrana sparsissime scrobiculato-punctata.

Long. 30 μ; lat. 49 μ; lat. isthm. 12 μ; crass. 15 μ.

Hab. Paddyfields, Heneratgodha.

This species is nearest to *C. Scenedesmus*, Delp., and especially its var. *dorsitruncatum*, Nordst. It can be distinguished, however, from all forms of *C. Scenedesmus* by its more depressed and flattened semicells, by its very much deeper constriction, and the extremely narrow closed sinus. The vertical view is also more narrowly elliptical, and the cell-wall exhibits peculiar scrobiculations somewhat distantly placed from each other.

159. COSMARIUM DEPRESSUM, Lund. in Act. R. Soc. Scient. Upsala, ser. 3, viii. 1871, p. 38. *Euastrum depressum*, Naeg. Gatt. einzell. Alg. p. 114, t. 7 c. fig. 2. Forma cellulis in medio apicum levissime et minute retusis.

Long. 26 μ; lat. 31·5 μ; lat. isthm. 6·5 μ; crass. 12 μ.

Hab. With the preceding species.

160. COSMARIUM TITHOPHORUM, Nordst. in Act. Univ. Lund. xvi. 1880, p. 6, t. 16. fig. 6.

Var. DEPRESSUM, var. n. (Pl. 20. fig. 29.) Var. paullo minor, semicellulis leviter depressis.

Long. 18·8–19 μ; lat. 20·5–22 μ; lat. isthm. 4·6 μ; crass. 13·4 μ.

Hab. With the preceding species.

C. Onychonema, Racib. (in Flora, lxxxi. 1895, Heft 1, p. 33, t. 4. fig. 12), appears to be an abnormal form of *C. tithophorum*; it is exactly the same size as the var. *depressum*, and only differs in the excentric position of the central protuberances.

161. COSMARIUM TINCTUM, Ralfs, Brit. Desm. 1848, p. 95, t. 32. fig. 7.

Hab. Paddyfields, Heneratgodha. Paddyfield between Kosgoda and Urahaighasmahendai.

162. COSMARIUM PYGMÆUM, Arch. in Quart. Journ. Micr. Sci. 1864, p. 174, t. 6. figs. 45–49; West, in Journ. Linn. Soc., Bot. xxix. p. 146, t. 20. fig. 24.

Var. SCHLIEPHACKIANUM, West & G. S. West, in Journ. Linn. Soc., Bot. xxxiii. 1898, p. 302.

Long. 9 μ; lat. 9 μ; lat. isthm. 2·3 μ; crass. 5·5 μ.

Hab. Paddyfields, Heneratgodha.

163. COSMARIUM BIREME, Nordst. in Vidensk. Medd. naturh. Foren. Kjöbenhavn, 1869, nos. 14–15, p. 212, t. 3. fig. 33.

Long. 13·5 μ; lat. 14·5 μ; lat. isthm. 2·5 μ; crass. 13 μ. (Pl. **20.** fig. 30.)

Hab. With the preceding species.

164. COSMARIUM BIPAXILLUM, sp. n. (Pl. **20.** fig. 31.) *C.* minutissimum, 1¼-plo latius quam longum, profunde constrictum, sinu lineari extremo subampliato; semicellulæ depresso-subsemicirculares, angulis basalibus rotundatis, apicibus levissime truncatis et emarginatis, supra et juxta isthmum (ad basin semicellularum) cum granulo magno; a vertice visæ anguste ellipticæ, granulo magno ad medium utrobique; a latere visæ subcirculares, cum granulo magno prope isthmum utrobique.

Long. 12·5 μ; lat. 15 μ; lat. isthm. 5·5 μ; crass. 7·5 μ.

Hab. Paddyfields, Heneratgodha.

This species can be compared with *C. bireme*, Nordst., from which it differs in the form of the semicells, and in the position, size, length, and direction of the central projection. In *C. bipaxillum* the central projection is granuliform, more basal in position, and is directed towards the isthmus.

It may also be compared with *C. Onychonema*, Racib.

165. COSMARIUM REGNELLII, Wille, in Bih. K. Sv. Vet.-Akad. Handl. 1884, viii. no. 18, p. 16, t. 1. fig. 34.

Long. 16–22 μ; lat. 14·5–19 μ; lat. isthm. 3·7–4·8 μ; crass. 7·5–9·5 μ.

Hab. In artificial tank, Peradeniya. Paddyfield between Kosgoda and Urahaighasmahendai.

166. COSMARIUM SUBREINSCHII, Schmidle, in Flora, lxxxii. 1896, Heft 2, p. 59, t. 7. fig. 24.

Var. OCELLATUM, var. n. (Pl. **20.** figs. 32, 33.) Var. semicellulis plus pyramidatis, apicibus convexo-truncatis, in centro tumore minore scrobiculum ferens.

Long. 26–28·5 μ; lat. 17–19 μ; lat. isthm. 4–5 μ; crass. 13·5 μ.

Hab. Paddyfields, Heneratgodha. Paddyfield between Kosgoda and Urahaighas mahendai.

167. COSMARIUM LÆVE, Rabenh. Flor. Europ. Algar. iii. 1868, p. 161; G. S. West, in Journ. Linn. Soc., Bot. xxvii. 1899, p. 386, t. 10. figs. 1–6.

Long. 15–18 μ; lat. 11·5–12·5 μ; lat. isthm. 2·8 μ.

Hab. In artificial tank, Peradeniya.

Var. SEPTENTRIONALE, Wille, in Öfvers. K. Vet.-Akad. Förh. 1879, no. 5, p. 43, t. 12. fig. 34; G. S. West, in Journ. Linn. Soc., Bot. xxvii. 1899, p. 387, t. 10. figs. 7–9.

Hab. Pond, Royal Botanical Gardens, Peradeniya.

168. COSMARIUM MENEGHINII, Bréb. in Ralfs, Brit. Desm. 1848, p. 96, t. 15. fig. 6.

Hab. In artificial tank, Peradeniya.

169. COSMARIUM NORIMBERGENSE, Reinsch, in Abhandl. naturhist. Gesellsch. Nürnberg, iii. 1866, p. 113, t. 9. fig. 2. *C. Hammeri*, Reinsch, var. *octogibbosum*, Reinsch, *l. c.* p. 112, t. 10. fig. 1. *C. octogibbosum*, W. B. Turn., 1892. *C. octogibbosum*, var. *indica*, W. B. Turn., 1892.

Long. 15–15·5 μ: lat. 12·5–13·3 μ; lat isthm. 3·5–4·3 μ; crass. 6·7–7·4 μ.

Hab. Paddyfield between Kosgoda and Urahaighasmahendai.

All the specimens observed were more depressed than normal examples.

170. COSMARIUM PUSILLUM, Arch in Pritch. Infus. ed. 4, 1861, p. 731. *Euastrum pusillum*, Bréb. in Mém. Soc. Sci. Nat. Cherbourg, iv. 1856, p. 125, t. 1. fig. 7.

Long. 6·8–9·6 μ; lat. 7–8·8 μ; lat. isthm. 2·7–3 μ; crass. 4·5 μ.

Hab. With the preceding species.

171. COSMARIUM MINIMUM, West & G. S. West, in Trans. Linn. Soc., Bot. ser. 2, v. 1895, p. 58, t. 8. fig. 10.

Hab. With the preceding species.

172. COSMARIUM EXIGUUM, Arch. in Proc. Dubl. Nat. Hist. Soc. iv. 1864, p. 49, t. 1. figs. 32, 33; Nordst. in Bih. K. Sv. Vet.-Akad. Handl. xxii. 1888, no. 8, p. 58, t. 6. fig. 12.

Hab. Pond, Royal Botanical Gardens, Peradeniya. Paddyfield between Kosgoda and Urahaighasmahendai.

173. COSMARIUM PSEUDEXIGUUM, Racib. in Pamietnik Akad. Umiej. w Krakow, Wydz. matem.-prz. x. 1885, p. 71, t. 10. fig. 8.

A slightly smaller form: long. 15 μ; lat. 7·5 μ; lat. isthm. 2·3 μ.

Hab. Paddyfields, Heneratgodha.

174. COSMARIUM REGNESII, Reinsch, in Abhandl. naturhist. Gesellsch. Nürnberg, iii. 1866, p. 112, t. 7. fig. 8.

Var. PRODUCTUM, var. n. (Pl. 20. fig. 35.) Var. angulis superioribus semicellularum sursum et extrorsum productis; tumoribus parvis 3 (ut in var. *montano*) in semicellula unaquaque; sinu magno subsemicirculari.

Long. 15–17 μ; lat. 13·5–15·5 μ; lat. isthm. 4·3–4·8 μ; crass. 8·5 μ.

Hab. Paddyfields, Heneratgodha.

175. Cosmarium americanum, Lagerh. in Öfvers. K. Sv. Vet.-Akad. Förh. 1885, no. 7, p. 240, t. 27. fig. 14. *Cosmarium coliferum*, Lagerh. in Bih. K. Sv. Vet.-Akad. Handl. xiii. 1888, Afd. 3, no. 9, p. 7, t. 1. fig. 5.

Long. 21–23 μ; lat. 14–19 μ; lat. isthm. 4·4–5·7 μ; crass. 9·7 μ.

Hab. With the preceding species.

Numerous forms of this species were observed, and they exhibited great variability of outline. Most of the examples more nearly approached the figure of *C. coliferum* than that of *C. americanum*, and some of them had the sinus more closed. In all cases there was a large yellowish thickening of the cell-wall in the centre of the semicells.

176. Cosmarium sulcatum, Nordst. Alg. Sandvic. 1878, p. 13, t. 1. fig. 18.

Var. incrassatum, var. n. (Pl. 20. figs. 36–38.) Var. cellulis profundissime constrictis, semicellulis in centro incrassatis et luteolis; a vertice visis ellipticis, incrassatis ad medium utrobique; a latere visis late ellipticis, lateribus incrassatis.

Zygospora globosa, glabra.

Long. 25·5–32·5 μ; lat. 19–26 μ; lat. isthm. 3·8–5·7 μ; crass. 10·5–15 μ: diam. zygosp. 34–35 μ.

Hab. With the preceding species.

This peculiar variety is thickened in the middle of each semicell instead of possessing the undulations of the typical plant.

177. Cosmarium contractum, Kirch. Krypt.-flora Schlesien, Alg. 1878, p. 147.

Long. 37 μ; lat. 28 μ; lat. isthm. 6 μ.

Hab. With the preceding species.

178. Cosmarium aversum, West & G. S. West, in Trans. Linn. Soc., Bot. ser. 2, v. 1895, p. 70, t. 8. figs. 6, 7.

Long. 31·5 μ; lat. 22 μ; lat. isthm. 5·3 μ.

Hab. With the preceding species.

179. Cosmarium globosum, Buln. in Hedwigia, i. 1861, p. 52, t. 9. fig. 8.

Var. Wollei, West & G. S. West, *l. c.* 1896, p. 252, t. 15. fig. 17.

Forma membrana crassa et scrobiculata. Long. 40 μ; lat. 32 μ; lat. isthm. 29·5 μ. (Pl. 20. fig. 42.)

Hab. With the preceding species.

Perhaps this plant may be a distinct species.

180. Cosmarium moniliforme, Ralfs, Brit. Desm. 1848, p. 107, t. 17. fig. 6. *Tessarthonia moniliformis*, Turp.

Hab. With the preceding species.

181. Cosmarium pseudoconnatum, Nordst. in Vidensk. Medd. f. d. natur. Foren. Kjöbenhavn, 1870, p. 214, t. 3. fig. 17.

Var. ELLIPSOIDEUM, var. n. (Pl. **20.** figs. 43–45.) Var. major, constrictione paullo profundiore, apicibus sæpe leviter depressis, a vertice visis late ellipticis; chromatophoris ut in forma typica.

Long. 56–63·5 μ; lat. 38·5–45 μ; lat. isthm. 32·5–38·5 μ; crass. 36 μ.

Hab. Paddyfields, Heneratgodha; and also between Kosgoda and Urahaighasmahendai. Pool in glen by roadside near Bandarawella (altit. 4000–5000 ft.).

Numerous examples of this variety were observed, and although the depth of the constriction varied considerably, yet all were more constricted than the typical plant. The vertical view was also broadly elliptical and not circular.

It agrees very well with Wolle's figure of *Cosmarium connatum*, var. *minor* (Wolle, Desm. U.S. t. 17. fig. 10), which is most probably a form of *C. pseudoconnatum*. Wolle appears to have been very confused in his ideas of *C. connatum* and *C. pseudoconnatum*.

From *C. pseudoconnatum*, var. *constrictum*, West (in Journ. Linn. Soc., Bot. xxix. p. 161, t. 21. fig. 17), it is distinguished by the less deep and differently-formed sinus, and by the different form of the semicells, as well as by the elliptical vertical view.

182. COSMARIUM PARVULUM, Bréb. in Mém. Soc. Sci. Nat. Cherbourg, iv. 1856, p. 133, t. 1. fig. 18. *C. obcuneatum*, West, in Journ. Linn. Soc., Bot. xxix. 1892, p. 162, t. 21. fig. 18.

Forma MINOR.

Long. 22 μ; lat. 10·5 μ; lat. isthm. 7·8 μ.

Hab. Paddyfields, Heneratgodha.

183. COSMARIUM TRACHYPOLUM, West & G. S. West, in Journ. Linn. Soc., Bot. xxxiii. 1897, p. 166, t. 8. figs. 14, 15.

Var. ELONGATUM, var. n. (Pl. **20.** figs. 39, 40.) Var. semicellulis elongatis et subconicis, polis rotundatis.

Long. 36–44 μ; lat. 16–17·5 μ; lat. isthm. 14·5–16 μ.

Hab. Paddyfields, Heneratgodha. Paddyfield between Kosgoda and Urahaighasmahendai.

184. COSMARIUM DORSOGRANULATUM, sp. n. (Pl. **20.** fig. 41.) *C.* parvum, duplo longius quam latum, profunde constrictum, sinu angusto-lineari extremo ampliato; semicellulæ semioblongæ, angulis basalibus rectangularibus et levissime rotundatis, lateribus rectis subparallelis, apicibus valde convexis, granulis minutis irregulariter dispositis, in parte superiore præditæ, in parte inferiore glabræ; a vertice visæ ellipticæ; a latere visæ oblongæ, angulis subrectangularibus; pyrenoidibus binis.

Long. 32 μ; lat. 15 μ; lat. isthm. 5·2 μ; crass. 12·4 μ.

Hab. Paddyfields, Heneratgodha.

185. COSMARIUM INCISUM, Josh. in Journ. Linn. Soc., Bot. xxi. 1886, p. 648, t. 24. figs. 28, 29.

Forma.

Long. 26·5 μ; lat. 19 μ; lat. isthm. 6 μ.

Hab. Rocks in Mahawelli Ganga.

Perhaps this plant should be renamed, as there is a *Cosmarium incisum*, Racib., 1885.

186. COSMARIUM MEDIOSCROBICULATUM, sp. n. (Pl. 21. fig. 1.) *C.* parvum, circiter tam longum quam latum, modice constrictum, sinu breviter lineari extremo ampliato et extrorsum valde ampliato; semicellulæ elliptico-subreniformes, apicibus late truncatis; membrana delicatissime granulata sed marginibus sinus et parte prope isthmum glabra, in centro scrobiculis 10–12 irregulariter dispositis; a vertice visæ compresso-ellipticæ, lateribus subparallelis scrobiculatis ad medium, polis subrotundatis minute granulatis; pyrenoidibus binis.

Long. 34·5–36·5 μ; lat. 33–34·5 μ; lat. isthm. 15 μ; crass. 18 μ.

Hab. Paddyfields, Heneratgodha.

From *C. trachydermum*, West & G. S. West, and *C. punctulatum*, Bréb., this species is distinguished by the outward form of the cell and the peculiar open sinus. It is also more minutely granulate, and possesses a number of well-marked scattered scrobiculations forming an irregular band across the centre of the semicells. The vertical view is also more compressed, and the poles not so rounded.

It also resembles to a certain extent *C. Raciborskii*, Lagerh., but the semicells are more broadly elliptical, the lateral angles are much more rounded, and the sinus is closed and then ampliated. The scrobiculations in the centre of the semicells are not present in *C. Raciborskii.*

187. COSMARIUM BIRETUM, Bréb. in Ralfs, Brit. Desm. 1848, p. 102, t. 16. fig. 5; G. S. West, in Journ. Linn. Soc., Bot. xxvii. 1899, p. 389, t. 10. figs. 22–28.

Long. 56 μ; lat. 45 μ; lat. isthm. 15 μ.

Hab. With the preceding species.

188. COSMARIUM MARGARITATUM, Roy et Biss. in Journ. Bot. xxxiv. 1886, p. 194.

Long. 62 μ; lat. 48 μ; lat. isthm. 16 μ.

Hab. In artificial tank, Peradeniya.

189. COSMARIUM SUBDECORATUM, West & G. S. West, in Journ. Linn. Soc., Bot. xxxiii. 1897, p. 165, t. 8. fig. 13.

Long. 57–63 μ; lat. 48–50 μ; lat. isthm. 15 μ.

Hab. Paddyfields, Heneratgodha. Paddyfield between Kosgoda and Urahaighasmahendai.

190. COSMARIUM DECORATUM, West & G. S. West, in Trans. Linn. Soc., Bot. ser. 2. v. 1895, p. 61, t. 7. fig. 21.

Var. DENTIFERUM, var. n. (Pl. 21. fig. 3.) Var. constrictione paullo profundiori, cum serie transversa verrucarum oblongarum 4 supra et juxta isthmum; cellulis a vertice visis ellipticis.

Long. 86 μ; lat. 64 μ; lat. isthm. 23 μ.

Hab. Paddyfields, Heneratgodha. Paddyfield between Kosgoda and Urahaighas mahendai.

191. Cosmarium quadrum, Lund. in Act. R. Soc. Scient. Upsala, ser. 3, viii. 1871, p. 25, t. 2. fig. 11.

Forma minor, ad var. *minus*, Nordst., accedens. Long. 60 μ; lat. 54 μ; lat. isthm. 18 μ; crass. 27 μ.

Hab. In artificial tank, Peradeniya.

192. Cosmarium Pardalis, Cohn, 'Desm. Bong.,' in Festschr. der natur. Ges. zu Halle, 1879, p. 9 (sep.), t. 11. fig. 8. *C. scabrum*, W. B. Turn. in K. Sv. Vet.-Akad. Handl. xxv. 1893, no. 5, p. 65, t. 9. fig. 32.

Long. 44–47 μ; lat. 43–45 μ; lat. isthm. 12–13 μ; crass. 20–21 μ. (Pl. 21. fig. 2.)

Hab. Paddyfields, Heneratgodha. Paddyfield between Kosgoda and Urahaighasmahendai.

The specimens observed from Ceylon were slightly smaller than Cohn's African examples, but were the same size as those we observed from Maine, U.S.A. (with zygospores). The semicells were rectangular with rounded angles, and all possessed large *hollow* granules, exactly like those figured by Cohn (*l. c.* fig. 8 *b*). Between the granules are also hexagons of punctulations.

C. scabrum, W. B. Turn., is unquestionably a poor representation of *C. Pardalis*, Cohn. In size it is intermediate between our specimens and the measurements given by Cohn. Turner's remark, "granulis . . . . 'rosettas' efficientibus," is quite applicable to the surface view of a specimen of *C. Pardalis* containing the chromatophores. There are two large pyrenoids in each semicell, and if the granules are focussed above these pyrenoids they present the rosette-like appearance which he describes; especially is this the case under a low magnification. This appearance, however, cannot be produced in an empty cell. The vertical view is oblong-elliptical with parallel sides and possesses no protuberances, and therefore the "rosette-like" appearance is due entirely to optical illusion.

193. Cosmarium Pseudobroomei, Wolle, 1884; Desm. U.S. p. 86, t. 51. figs. 36, 37.

Long. 34–38 μ; lat. 31–36 μ; lat. isthm. 8·5–12 μ; crass. 16–17·5 μ. (Pl. 21. fig. 4.)

Hab. With the preceding species.

194. Cosmarium Portianum, Arch. in Quart. Journ. Micr. Sci. viii. 1860, p. 235, t. 11. figs. 8, 9.

Var. orthostichum, Schmidle, in Berichte, Deutsch. Bot. Ges. xi. 1893, Heft 10, p. 549, t. 28. fig. 7.

Forma minor: long. 20 μ; lat. 14·5 μ; lat. isthm. 5 μ; crass. 10 μ.

Hab. With the preceding species.

195. Cosmarium amœnum, Bréb. in Ralfs, Brit. Desm. 1848, p. 102, t. 17. fig. 3.
Hab. Paddyfield between Kosgoda and Urahaighasmahendai.

196. Cosmarium tessellatum, Nordst. in Act. Univ. Lund. xvi. 1880, p. 7. *Disphinctium tessellatum*, Delponte, in Mem. Accad. Sci. Torino, ser. 2, xxx. 1878, p. 136, t. 21. figs. 10–13.
Long. 105 μ; lat. 60 μ; lat. isthm. 46 μ.
Hab. With the preceding species.

197. Cosmarium quadrifarium, Lund. in Act. R. Soc. Scient. Upsala, ser. 3, viii. 1871, p. 32, t. 3. fig. 12.
Forma minor: long. 34·5–37 μ; lat. 23–26 μ; lat. isthm. 5·2–6 μ; crass. 15–17 μ.
Hab. With the preceding species.

198. Cosmarium binum, Nordst. in Wittr. & Nordst. Alg. Exsic. 1880, no. 383, ex De Toni, Syll. Alg. i. 993. Forma cellulis 1¼–1½-plo longioribus, semicellulis variabilibus in ambitu sed apicibus semper late truncatis.
Long. 41–61 μ; lat. 30–44 μ; lat. isthm. 12–17 μ.
Hab. Surface of pond, Royal Botanical Gardens, Peradeniya. Paddyfields, Heneratgodha. Paddyfield between Kosgoda and Urahaighasmahendai. Among *Spirogyra* sp., in little muddy backwaters, Mahawelli Ganga. Pool in glen by roadside, near Bandarawella (altit. 4000–5000 ft.). Muddy bottom of pool at foot of Hakgala Rock (altit. 6000 ft.).

199. Cosmarium haaboliense, Wille, in Christiania Vid.-Selsk. Forhandl. 1880, no. 11, p. 25, t. 1. fig. 6.

Var. protractum, West & G. S. West, in Trans. Linn. Soc., ser. 2, Bot. v. 1895, p. 65, t. 7. fig. 13.
Long. 22 μ; lat. 20 μ; lat. isthm. 6 μ; crass. 12 μ.
Hab. Pond, Victoria Park, Colombo.

200. Cosmarium pterophorum, sp. n. (Pl. 21. figs. 6, 7.) *C.* minutissimum, paullo latius quam longum, profundissime constrictum, sinu acutangulo subaperto; semicellulæ oblongo-ellipticæ, granulis minutissimis paucis instructæ, in centro papilla magna præditæ; a vertice visæ anguste ellipticæ, in medio utrobique cum papilla acuta et elongata; a latere visæ globosæ, cum papilla magna acuta et introrsum geniculata utrobique semicellularum.

Long. 9·5–11 μ; lat. 10–12 μ; lat. isthm. 2·5–2·8 μ; crass. sine papill. 5·5 μ, cum papill. 12 μ.

Hab. Paddyfields, Heneratgodha.

This species can be compared with *C. spyridion*, West & G. S. West.

201. COSMARIUM SPYRIDION, West & G. S. West, in Trans. Linn. Soc., ser. 2, Bot. v. 1895, p. 64, t. 7. fig. 26.

Long. 13 μ; lat. 13·5 μ; lat. isthm. 4·8 μ; crass. 9 μ.

Hab. Paddyfield between Kosgoda and Urahaighasmahendai.

202. COSMARIUM BLYTTII, Wille, in Christiania Vid.-Selsk. Forhandl. 1880, no. 11, p. 25, t. 1. fig. 7.

Hab. Paddyfields, Pandure. Paddyfield between Kosgoda and Urahaighasmahendai.

203. COSMARIUM SUBCOSTATUM, Nordst. in Öfvers. K. Vet.-Akad. Förh. 1876, no. 6, p. 37, t. 12. fig. 13.

Hab. Among *Spirogyra* sp., in fast-running stream, Peradeniya.

204. COSMARIUM TRIPAPILLATUM, West & G. S. West, in Trans. Linn. Soc., ser. 2, Bot. v. 1895, p. 65, t. 7. fig. 24.

Long. 15 μ; lat. 14·5 μ; lat. isthm, 3·5 μ; crass. 9·7 μ.

Hab. Paddyfields, Heneratgodha.

205. COSMARIUM BISCROBICULATUM, sp. n. (Pl. 21. fig. 5.) *C.* minutum, paullo longius quam latum, profundissime constrictum, sinu aperto subrotundato; semicellulæ suboblongæ, lateribus rotundatis, apicibus subrectis, granulis minutissimis perpaucis instructæ (apicibus subglabris), in centro scrobiculo magno instructæ; a vertice visæ oblongæ, polis rotundatis, in medio utrobique cum scrobiculo magno; a latere visæ circulares cum scrobiculo magno utrobique.

Long. 15 μ; lat. 14 μ; lat. isthm. 4 μ; crass. 7 μ.

Hab. Paddyfields, Heneratgodha.

206. COSMARIUM TAXICHONDRUM, Lund. in Act. R. Soc. Scient. Upsala, ser. 3, viii. 1871, p. 39, t. 2. fig. 13.

Var. NUDUM, W. B. Turn. in K. Sv. Vet.-Akad. Handl. xxv. 1893, no. 5, p. 60, t. 8. fig. 64.

Long. 42 μ; lat. 42 μ; lat. isthm. 11 μ; crass. 22 μ.

Hab. With the preceding species.

207. COSMARIUM PSEUDOTAXICHONDRUM, Nordst. in Öfvers. K. Vet.-Akad. Förh. 1877, no. 3, p. 20, t. 2. fig. 5. Var. marginibus lateralibus semicellularum subundulatis, verrucis tribus infra et juxta apicem; membrana punctulata.

Long. 26–28·5 μ; lat. 31–33 μ; lat. isthm. 7·5–8·5 μ; crass. 19 μ.

Hab. With the preceding species.

The forms observed of this species greatly resembled var. *africanum*, West & G. S. West (in Journ. Bot. xxxv. 1897, p. 173, t. 367. fig. 14), only differing in the slightly undulate lateral margins and in the somewhat larger subapical verrucæ.

208. Cosmarium Haynaldii, Schaarschm. in Magyar. Tudom. Akad. math. és Termész. Közlemények, xviii. 1882, p. 267, t. 1. fig. 5.

A slightly more angular form with the apical papillæ very prominent and spine-like.

Long. (cum papill.) 31 μ; lat. 30 μ; lat. isthm. 7·5 μ; crass. 16 μ.

Hab. With the preceding species.

209. Cosmarium Freemanii, sp. n. (Pl. 21. figs. 8–10.) *C.* parvum, $1\frac{1}{8}$-plo longius quam latum, profunde constrictum, sinu angusto-lineari extremo ampliato; semicellulæ late pyramidato-trapeziformes, angulis inferioribus subrectangularibus, lateribus convexis in parte inferiore denticulis 4 (summis maximis) præditis, angulis superioribus dente obtuso singulo instructis, apicibus truncatis subrectisque, granulo magno intra angulum inferiorem unumquemque, serie granulorum magnorum 3 infra apicem (nonnunquam granulis bipartitis), granulis magnis 2 supra centrum semicellularum; a vertice visæ ellipticæ, polis granulis distantibus 3 et granulis magnis 3 ad medium utrobique instructæ; a latere visæ subcirculares, granulis magnis binis supra medium utrobique et dente obtuso ad medium apicis; pyrenoidibus binis.

Long. 31–33 μ; lat. 26–28 μ; lat. apic. semicell. 13 μ; lat. isthm. 8 μ; crass. 18–19 μ.

Hab. Paddyfields, Heneratgodha.

Compare with *C. trinotatum*, Eichl. & Gutw. (in Rozpraw. Wydz. Akad. Umiej. Krakow, 1894, p. 166, t. 4. fig. 14), from which it differs in dimensions and in the arrangement of its granules.

210. Cosmarium cuneatum, in Josh. 'Burm. Desm.,' in Journ. Linn. Soc., Bot. xxi. 1886, p. 647, t. 24. figs. 17, 18.

Long. 35 μ; lat. 35–37 μ; lat. isthm. 8–9·5 μ; crass. 15 μ. (Pl. 21. fig. 11.)

Hab. With the preceding species.

Joshua's figure of Burmese specimens of this species is so very poor and inaccurate that we feel compelled to give a figure of some examples from Ceylon. The vertical view was well figured by Lagerheim in Bih. till K. Sv. Vet.-Akad. xiii. Afd. 3, no. 9, t. 1. fig. 4 *c*.

The basal angles of the semicells are faintly emarginate, and on each lateral margin are three very small papillæ; otherwise the margin is quite smooth. The fourteen large flattened granules are entirely within the margin and are uniform in size.

The cells are most frequently met with in pairs, not seeming to separate very readily after division.

C. cuneatum, ? var. *indicum*, W. B. Turn. (in K. Sv. Vet.-Akad. Handl. xxv. 1893, no. 5, p. 62, t. 9. fig. 14), most certainly does not belong to *C. cuneatum*, Josh.

211. Cosmarium spinuliferum, sp. n. (Pl. 21. figs. 12, 13.) *C.* parvum, tam longum quam latum vel paullo longius, profunde constrictum, sinu angusto-lineari extremo subampliato; semicellulæ truncato-semicirculares, angulis rotundatis, apicibus subrectis, spinis brevibus (vel papillis acutis) 6–7 ad marginem lateralem unumquemque et seriebus irregularibus 2–3 intra marginem, intra apicem spinis 4–6 instructæ, in

centro semicellularum granulis maximis tribus horizontaliter dispositis et serie granulorum minorum 4 supra granula maxima 3; a vertice visæ ellipticæ, granulis maximis tribus ad medium utrobique, polis denticulato-spinatis; a latere visæ subcirculares, granulis magnis 2 supra medium utrobique, apicibus denticulatis.

Long. 30 μ; lat. (cum spinul.) 30 μ; lat. isthm. 8 μ; crass. 17 μ.

Hab. Paddyfields, Heneratgodha.

212. **Cosmarium ceylanicum**, sp. n. (Pl. 21. figs. 14, 15.) *C.* submediocre, $1\frac{1}{7}$–$1\frac{1}{3}$-plo longius quam latum, profundissime constrictum, sinu angusto-lineari extremo ampliato; semicellulæ pyramidato-trapeziformes, angulis inferioribus subrotundatis, lateribus leviter convexis 5–6-noduloso-granulatis, angulis superioribus denticulo prominenti singulo præditis, apicibus truncatis leviter convexis cum serie granulorum depressorum magnorum 4 infra et juxta marginem, in centro semicellularum verrucis depressis rotundatis 3 (circ.) et annulo scrobiculorum 5–6 circa verrucam unamquamque; a vertice visæ ellipticæ, polis rotundo-truncatis, bidenticulatis, verrucis depressis tribus ad medium utrobique; a latere visæ obovato-circulares, verrucis depressis binis ad medium et granulo magno prope apicem utrobique; pyrenoidibus binis.

Long. 33–42 μ; lat. 30–33 μ; lat. apic. semicell. 13·5–15·5 μ; lat. isthm. 5·5–7·5 μ; crass. 22 μ.

Hab. Paddyfields, Heneratgodha.

213. **Cosmarium Wallichii**, nob. *Euastrum Clepsydra*, G. C. Wallich, in Ann. & Mag. Nat. Hist. ser. 3, v. 1860, p. 284, t. 14. figs. 19–21; W. B. Turner, in K. Sv. Vet.-Akad. Handl. xxv. 1893, no. 5, p. 76, t. 9. fig. 51.

Long. 26·5 μ; lat. 27·5 μ; lat. isthm. 8 μ; crass. 15 μ.

Hab. In artificial tank, Peradeniya.

This plant undoubtedly belongs to the genus *Cosmarium* and not to *Euastrum*, being similar in outline to such species as *C. porrectum*, Nordst. Two species of *Cosmarium* have already been given the name "*C. Clepsydra*" (*cf.* Nordst. in Vidensk. Medd. natur. Foren. Kjöbenhavn, 1869, p. 212, t. 3. fig. 29; and Delponte, in Mem. Accad. Sci. Torino, ser. 2, xxx. 1877, p. 8, t. 7. figs. 35, 36), so that the name "*C. Wallichii*" had to be adopted.

Genus Spondylosium, Bréb.

214. **Spondylosium compactum**, sp. n. (Pl. 22. figs. 29, 30.) *S.* parvum, filis non tortis, sine vagina mucosa; cellulæ circiter tam longæ quam latæ, subquadratæ, profunde constrictæ, sinu lineari; semicellulæ oblongo-rectangulares, angulis subrotundatis, lateribus subrectis, apicibus leviter concavis; semicellulæ a vertice visæ elliptico-oblongæ, a latere visæ subcirculares; membrana glabra.

Long. cell. 9–9·5 μ; lat. 9·5 μ; lat. isthm. 3·4 μ; crass. 4·6 μ.

Hab. Paddyfield between Kosgoda and Urahaighasmahendai.

Owing to the concave nature of the apices there is a small aperture visible between any two contiguous cells of the filament.

Genus PHYMATODOCIS, Nordst.

215. PHYMATODOCIS IRREGULARE, Schmidle, in Engler's Bot. Jahrb. xxvi. 1898, Heft 1, p. 13, t. 1. figs. 3–9.

Long. 24–29 μ; lat. 46–50 μ; lat. isthm. 23–29 μ. (Pl. 22. figs. 32–34.)

Hab. Paddyfields, Heneratgodha.

In all the specimens we observed of this plant the lateral margins of the semicells were undulate, as in *P. Nordstedtiana*, Wolle, and in the vertical view the angles (both long and short) were also very slightly retuse at the apex, exactly as we found them in Wolle's species (*cf.* Trans. Linn. Soc., ser. 2, Bot. v. 1895, t. 12. fig. 6 *d*).

Genus STAURASTRUM, Meyen; emend. Ralfs.

216. STAURASTRUM DEJECTUM, Bréb. in Menegh. Synops. Desm. 1840, p. 227. *Binatella dejecta*, Bréb., 1835.

Long. sine spin. 19–21 μ; lat. sine spin. 18·5–22 μ; long. spin. 5·2–5·8 μ; lat. isthm. 5·7–6 μ.

Hab. Paddyfields, Heneratgodha.

217. STAURASTRUM CONNATUM, Roy & Biss. in Journ. Bot. xxiv. 1886, p. 237. *S. dejectum*, var. *connatum*, Lund.

Long. sine spin. 25 μ; lat. sine spin. 23 μ; long. spin. circ. 9·5 μ; lat. isthm. 8·5 μ.

Hab. With the preceding species.

218. STAURASTRUM CUSPIDATUM, Bréb. in Menegh. Synops. Desm. 1840, p. 226; Ralfs, Brit. Desm. 1848, p. 122, t. 21. fig. 1.

Forma INCURVA, Hiemerl, in Verhand. der k. k. zool.-bot. Ges. Wien, 1891, p. 604, t. 5. fig. 19.

Long. 18–21 μ; lat. sine spin. 14·5–15·5 μ; lat. isthm. 4·4 μ.

Hab. With the preceding species.

219. STAURASTRUM UNICORNE, W. B. Turn. in K. Sv. Vet.-Akad. Handl. xxv. 1893, no. 5, p. 107, t. 15. fig. 16. *Distrib.* Bengal; Central China.

Var. ECORNE, nob. (*S. ecorne*, W. B. Turn. *l. c.* t. 15. fig. 17). *Hab.* Bengal.

Var. EXIMIUM, nob. (*S. eximium*, W. B. Turn. *l. c.* p. 131, t. 17. fig. 6). *Hab.* Bengal.

Var. NODIFERUM, nob. (*S. nodiferum*, W. B. Turn. *l. c.* p. 130, t. 14. fig. 26). *Hab.* Bengal

Var. OBESUM, West & G. S. West, in Trans. Linn. Soc., ser. 2, Bot. v. 1896, p. 256, t. 16. fig. 12. *Hab.* U.S.A.

The four plants described by Turner as *S. unicorne*, *S. ecorne*, *S. eximium*, and *S. nodiferum* appear to us to represent different types of ornamentation of one species, the general outline of which is represented by *Staurastrum unicorne*. That they can only be regarded as varieties of one species is evident from their close resemblance and from the fact of the occurrence of yet another variety (from Ceylon) slightly different from any of the above, but connecting typical *S. unicorne* with its varieties *nodiferum* and *eximium*.

Var. CEYLANICUM, var. n. (Pl. 21. figs. 16, 17.) Var. apicibus capitatis processuum cum annulo denticulorum 4 et spina terminali elongata introrsum curvata instructis; denticulo parvo ad marginem sinus ut in var. *nodifero*.

Long. sine proc. 22–23 μ; long. cum proc. 25–26 μ; lat. cum proc. sed sine spin. 27–31 μ; lat. cum spin. 46–50 μ; lat. isthm. 8 μ.

Hab. Paddyfields, Heneratgodha.

The apices of the processes of this variety differ from those of var. *nodiferum* and var. *eximium* in the possession of the long and slightly incurved spines present in typical *S. unicorne*.

220. STAURASTRUM BIFIDUM, Bréb. in Ralfs, Brit. Desm. 1848, p. 215; Lund. in Nov. Act. Soc. Scient. Upsala, ser. 3, viii. 1871, p. 62, t. 4. fig. 2.

All the forms seen had a more or less straight apex, and the two spines at each angle were not in a horizontal plane. Long. 31 μ; lat. sine spin. 33–35 μ; lat. isthm. 11 μ.

Hab. Paddyfields, Heneratgodha.

221. STAURASTRUM BRASILIENSE, Nordst. in Vidensk. Medd. f. d. naturh. Foren. Kjöbenhavn, 1869, p. 227, t. 4. fig. 39.

Var. TRICORNUTUM, nob. *S. tricornutum*, Wolle, 1880; Desm. U.S. p. 145, t. 47. figs. 1, 2.

Forma paullo minor. Long. sine spin. 80 μ; lat. sine spin. 71 μ, cum spin. 111 μ; lat. isthm. 25 μ.

Hab. Paddyfield between Kosgoda and Urahaighasmahendai.

There is no doubt whatever that *S. tricornutum*, Wolle, is a variety of *S. brasiliense*, Nordst., as it only differs in the convex apex of the semicells and in the triangular vertical view. It is also considerably larger than typical *S. brasiliense*, but no larger than *S. brasiliense* var. *Lundellii*, West & G. S. West.

222. STAURASTRUM ENSIFERUM, W. B. Turn. in K. Sv. Vet.-Akad. Handl. xxv. 1893, no. 5, p. 109, t. 14. fig. 22.

Long. sine spin. 34–37 μ, cum spin. 49–54 μ; lat. sine spin. 29–32·5 μ, cum spin. 42–46 μ; lat. isthm. 13·5 μ.

Hab. Paddyfields, Heneratgodha.

Some specimens possess only two spines at each angle, others possess three, and it is not uncommon to find an example in which some angles are furnished with two spines and the others with three.

223. STAURASTRUM FREEMANII, sp. n. (Pl. 21. fig. 21.) *S.* mediocre, pæne tam longum quam latum (sine spinis), profunde constrictum, sinu aperto; semicellulæ obverse subsemicirculares, angulis in processus breves tenues solidos productis, apicibus processuum profunde bifurcatis, aculeis latissime divergentibus, apicibus semicellularum subrectis parte mediana paullo elevata, angulis lateralibus elevationis spinis horizontalibus præditis; a vertice visæ subanguste ellipticæ, polis in processus breves productis, spinis validis subdivergentibus binis infra basin processuum.

Long. (sine spin.) 29 μ; lat. sine proc. 32 μ, cum proc. 63 μ; lat. isthm. 11 μ; crass. 14 μ.

Hab. Paddyfields, Heneratgodha.

Var. TRIQUETRUM, var. n. (Pl. 21. fig. 22.) Var. paullo minor, semicellulis a vertice visis triangularibus; ceteris ut in forma typica.

Long. (sine proc.) 22 μ; lat. sine proc. 25 μ, cum proc. 49 μ; lat. isthm. 8 μ.

Hab. With the typical form.

Perhaps the nearest species to *S. Freemanii* is *S. patens*, W. B. Turn. (K. Sv. Vet. Akad. Handl. xxv. 1893, no. 5, p. 108, t. 14. fig. 21), from which it differs in its smooth lateral margins, its much more produced angles, and in the characteristic pairs of spines at the apices. The *solid* processes are also peculiar.

224. STAURASTRUM ALTERNANS, Bréb. in Ralfs, Brit. Desm. 1848, p. 132, t. 21. fig. 7.

Var. DIVERGENS, var. n. (Pl. 21. fig. 18.) Var. minor, apicibus semicellularum concavis, angulis levissime dilatatis (subcapitatis) sursum leviter divergentibus; a vertice visis ut in forma typica sed angulis levissime subcapitatis.

Long. 17 μ; lat. 17–18 μ; lat. isthm. 5·5 μ.

Hab. With the preceding species.

This variety may perhaps be *S. sinense,* Lütkem. (in Annalen des k. k. naturhist. Hofmuseums, Wien, xv. 1900, p. 124, t. 6. figs. 39, 40), but it differs from the latter in the form of its semicells.

225. STAURASTRUM DILATATUM, Ehrenb. Infus. 1838, p. 143, t. 10. fig. 13; Ralfs, Brit. Desm. 1848, p. 133, t. 21. fig. 8.

Var. OBTUSILOBUM, De Not. Desm. Ital. 1867, p. 53, t. 4. fig. 47; Nordst. in K. Sv. Vet.-Akad. Handl. xxii. 1883, no. 8, p. 41, t. 4. fig. 19.

Long. 28·5 μ; lat. 30–32 μ; lat. isthm. 8·5 μ.

Hab. Paddyfields, Heneratgodha. Paddyfield between Kosgoda and Urahaighasmahendai.

226. **Staurastrum retusum**, W. B. Turn. in K. Sv. Vet.-Akad. Handl. xxv. 1893, no. 5, p. 104, t. 13. fig. 13.

Var. **punctulatum**, Eichler & Gutw. in Rozpraw. Wydz. Akad. Umiej. Krakow, 1894, p. 174, t. 5. fig. 44.

Long. 15·5–24 μ; lat. 15·5–23 μ; lat. isthm. 3·6–5·5 μ.

Hab. Paddyfields, Heneratgodha.

The specimens observed varied very greatly in size. The cell-wall is minutely punctulate all over, the punctulations being more marked at the angles, and in many cases the angles are distinctly thickened. It is highly probable that the var. *punctulatum* is identical with the typical form, as Turner's description of Wallich's figure is not definite as implied by the expression "glabræ ?," and probably Wallich's figure is not good.

227. **Staurastrum muticum**, Bréb. in Menegh. 'Synops. Desm.,' in Linnæa, xiv. 1840, p. 228; Ralfs, Brit. Desm. 1848, p. 125, t. 21. fig. 4.

Long. 33·5 μ; lat. 29 μ; lat. isthm. 9 μ.

Hab. With the preceding species.

228. **Staurastrum giganteum**, sp. n. (Pl. 21. fig. 20.) *S.* permagnum, ellipsoideum, circiter 1⅓-plo longius quam latum, profundissime constrictum, sinu sublineari et paullo aperto; semicellulæ semiellipticæ, angulis basalibus rectangularibus incrassatis et submucronatis; a vertice visæ triangulares, lateribus paullo convexis, angulis incrassatis; membrana punctulata.

Long. 160 μ; lat. 110 μ; lat. isthm. 32 μ.

Hab. Paddyfield between Kosgoda and Urahaighasmahendai.

This is a very large Desmid, and at first we thought it a unique species of the genus, but since we wrote our description we have observed that it somewhat resembles a recently described Chinese species—*S. Zahlbruckneri*, Lütkem. (in Annalen des k. k. naturh. Hofmuseums, Wien, xv. 1900, p. 125, t. 6. figs. 41–43). *S. giganteum* is easily distinguished from the latter species by its much larger size, its deeper constriction and open sinus, and by its vastly different basal angles. The sides of the vertical view are also more convex, and the angles are not so rounded.

229. **Staurastrum villosum**, sp. n. (Pl. 21. fig. 19.) *S.* parvum, pæne tam longum quam latum (sine spinis), profunde constrictum, sinu acutangulo aperto; semicellulæ subellipticæ, spinis longissimis delicatissimis subcurvatis numerosis præditæ; a vertice visæ triangulares, lateribus levissime concavis, angulis acute rotundatis, spinis longissimis curvatis angulos versus confertioribus.

Long. sine spin. 27 μ, cum spin. 35 μ; lat. sine spin. 25 μ, cum spin. 44 μ; long. spin. 7·5–10 μ; lat. isthm. 7 μ.

Hab. Paddyfields, Heneratgodha.

This plant may be compared with *S. sagittiferum*, Börg. (in Vidensk. Medd. naturh. Foren. Kjöbenhavn, 1890, p. 950, t. 5. fig. 46), but it differs from that species entirely, in the larger number, the greater delicacy, and different arrangement of the spines.

The spines are also more numerous at the angles, and differ from those of any other spiny *Staurastrum* in being directed towards the angles. Most of the spines are bent at their base, and this curvature in the direction of the angles of the semicells is one of the most marked features of *S. villosum*.

230. STAURASTRUM SUBLÆVISPINUM, West & G. S. West, in Journ. Linn. Soc., Bot. xxxiii. 1898, p. 314, t. 18. figs. 20–22.

Forma tam longum quam latum (cum proc.), processibus paullo brevioribus et apicibus acutis minute incrassatis. Long. cum proc. 23 μ; lat. cum proc. 24 μ; lat. isthm. 6·5 μ.

Hab. With the preceding species.

231. STAURASTRUM HENERATGODHENSE, sp. n. (Pl. **21.** fig. 23.) *S.* subparvum, circiter tam longum quam latum, profunde constrictum; semicellulæ late transverse ellipticæ, polis in processus breves crassos productis, apicibus processuum subtruncatis bispinatisque, dorso convexo cum verrucis parvis bispinatis 4 ornato, ventre valde inflato cum denticulo ad basin processuum intra sinum; a vertice visæ subrhomboideæ, polis productis et bispinatis, intra polo unoquoque cum verruca parva bispinata singula, medium semicellularum versus verrucis parvis bispinatis 2 utrobique.

Long. 32–33 μ; lat. sine spin. 31–32·5 μ, cum spin. 36 μ; lat. isthm. 7·5 μ; crass. 19·5 μ.

Hab. Paddyfields, Heneratgodha.

The arragement of the warts on the dorsal surface of this *Staurastrum* is best seen in vertical view. There are four double-spined warts, one pair on each side of the apex, and, in addition, a single somewhat smaller double-spined wart between each of these pairs and the end of the process.

232. STAURASTRUM QUADRICORNUTUM, Roy & Biss. in Journ. Bot. xxiv. 1886, p. 240, t. 268. fig. 4.

Var. PATENS, var. n. (Pl. **21.** fig. 24.) Var. semicellulis depressis, apicibus latis subrectis, processibus subhorizontaliter dispositis.

Long. 23 μ; lat. sine proc. 14 μ, cum proc. 29 μ; lat. isthm. 5·3 μ.

Hab. With the preceding species.

233. STAURASTRUM GEMELLIPARUM, Nordst. in Vidensk. Medd. f. d. naturh. Foren. Kjöbenhavn, 1869, p. 230, t. 4. fig. 54.

Long. sine proc. 19 μ, cum proc. 26 μ; lat. sine proc. 13·4 μ, cum proc. 23·5 μ; lat. isthm. 4·3 μ. (Pl. **21.** fig. 25.)

Hab. With the preceding species.

234. STAURASTRUM HANTZSCHII, Reinsch, Spec. Alg. Fung. p. 129, t. 22 D. figs. 1, 4, 6.

Var. CONGRUUM, West & G. S. West, in Trans. Linn. Soc., Bot. ser. 2, v. 1896, p. 257,

t. 16. fig. 15. *Staurastrum Renardi*, Reinsch, var. *congruum*, Racib., 1900. *S. Hantzschii*, Reinsch, var. *depauperatum*, Gutw., 1892. *S. intricatum*, Delponte (ex parte).

Hab. With the preceding species.

235. Staurastrum leptacanthum, Nordst. in Vidensk. Medd. naturh. Foren. Kjöbenh. 1869, p. 229, t. 4. fig. 46.

Long. sine proc. 24–36·5 μ, cum proc. 44–67 μ; lat. sine proc. 14·5–22 μ, cum proc. 38–54 μ; lat. isthm. 9·5–13·5 μ. (Pl. 21. figs. 29, 30.)

Hab. Paddyfields, Heneratgodha.

The specimens observed from Ceylon varied greatly in size and all possessed 15 processes on the semicell, 9 in the inferior and 6 in the superior whorl. In this they resembled the form of *S. leptacanthum* described and figured from Florida, U.S.A. (*cf.* West & G. S. West, 'Some Desm. U.S.,' in Journ. Linn. Soc., Bot. xxxiii. 1898, p. 319, t. 18. fig. 12).

S. tohopekaligense, Wolle, 1885 (syn. *S. nonanum*, W. B. Turn., 1893), is a species which very closely resembles *S. leptacanthum*, Nordst. It exhibits the same variability with regard to the number of the processes in the upper and lower whorls, and the typical forms of each species possess long smooth processes which are deeply *bifurcate*.

S. leptacanthum has more globular semicells and a much broader isthmus than *S. tohopekaligense*, and the processes are relatively a little longer and more delicate. The vertical view of *S. leptacanthum* is always subcircular in outline, whereas that of *S. tohopekaligense* is always triangular (or rarely quadrangular).

S. japonicum, W. B. Turn., is merely a form of *S. leptacanthum*, with slightly shorter processes which are not so deeply bifurcate.

236. Staurastrum tohopekaligense, Wolle, 1885; Freshw. Alg. U.S. 1887, p. 45, t. 59. figs. 4, 5. *S. nonanum*, W. B. Turn. in K. Sv. Vet.-Akad. Handl. xxv. 1893, no. 5, p. 119, t. 15. fig. 14.

Wolle's figures of this species do not represent the plant very well, those of Turner (under the name of *S. nonanum*) being much nearer the actual plant, American specimens of which we have observed in material received from the late Rev. Francis Wolle. We give a figure of the vertical view of one of these American specimens (Pl. 21. fig. 26). *S. tohopekaligense* exhibits a certain amount of variation in size, in the form of the body, and in the length of the processes. There are two whorls of processes on each semicell, the *lower whorl* consisting either of three processes (one at each angle) or of nine processes (one at each angle and a pair on each lateral margin), and the *upper whorl* consisting of six processes. Thus the total number of processes on each semicell may be either nine or fifteen. Each process is very slightly dilated at the end and is *always bifurcate.*

Schmidle suggested (in Engler's Bot. Jahrbüch. xxvi. 1898, Heft 1, p. 52) that *S. nonanum* should be placed as a variety of *S. tohopekaligense*, but as it does not differ in any respect from Wolle's species we fail to see how he would define the variety.

Var. TRIFURCATUM, West & G. S. West, 'Freshw. Alg. Madag.,' in Trans. Linn. Soc., ser. 2, Bot. v. 1895, p. 80, t. 9. fig. 8.

Long. sine proc. 36 μ, cum proc. 54 μ; lat. sine proc. 27 μ, cum proc. 50 μ; lat. isthm. 9·5 μ. (Pl. 21. fig. 27.)

Hab. Paddyfields, Heneratgodha.

The specimens observed were somewhat smaller than the examples from Madagascar; most of them possessed nine processes in the lower whorl, but one individual was observed in which one semicell possessed nine processes in the lower whorl and the other semicell only three (*cf.* Pl. 21. fig. 27). Thus the extremes of variation (for this species) in the number of the processes were present in the same specimen.

Var. INSIGNE, var. n. (Pl. 21. fig. 28.) Var. cellulis multe majoribus, processibus 18 (inferioribus 9 et superioribus 9) longioribus et apicibus profundissime trifurcatis.

Long. sine proc. 87 μ, cum proc. 158 μ; lat. sine proc. 57 μ, cum proc. 129 μ; lat. isthm. 23 μ.

Hab. Paddyfield between Kosgoda and Urahaighasmahendai.

This is much the largest of the varieties of *S. tohopekaligense*, and is distinguished by its long deeply trifurcate processes. The specimen observed possessed nine processes in each whorl; but this may not be a definite character, as we have shown that the number of processes in each whorl varies considerably in varieties of this species.

237. STAURASTRUM SEXANGULARE, Rabenh. Krypt. Flor. Sachs. 1863, p. 621; Lundell. in Nov. Act. R. Soc. Scient. Upsala, ser. 3, viii. 1871, p. 71, t. 4. fig. 9. *Didymocladon sexangularis*, Buln. in Hedwig. i. 1861, p. 51, t. 9 A. fig. 1.

Forma processibus basalibus subelongatis attenuatis et inflexioribus, denticulis numerosioribus et acutioribus. Long. sine proc. 36 μ, cum proc. 54–58 μ; lat. cum proc. 67 μ; lat. isthm. 10·5 μ. (Pl. 21. fig. 34.)

Hab. Paddyfields, Heneratgodha.

Var. SUBGLABRUM, var. n. (Pl. 21. fig. 35.) Var. processibus inferioribus sursum curvatis, marginibus superioribus glabris, marginibus inferioribus cum denticulis binis; processibus superioribus brevioribus et glabris.

Long. sine proc. 38·5 μ, cum proc. 48 μ; lat. sine proc. 30 μ, cum proc. 62 μ; lat. isthm. 9·5 μ.

Hab. Paddyfields, Heneratgodha.

238. STAURASTRUM ZONATUM, Börg. 'Desm. Brasil.,' in Vidensk. Medd. naturh. Foren. Kjöbenhavn, 1890, p. 46, t. 5. fig. 48.

Var. CEYLANICUM, var. n. (Pl. 21. figs. 31, 32.) Var. semicellulis nonnunquam longioribus subrectangularibusque, apicibus subdepressis; margine inferiore processuum trinoduloso, apicibus processuum tridenticulatis; a vertice visis 6-radiatis, processibus trinodulosis utrobique, in centro annulo denticulorum singulorum 6 instructo.

Long. sine proc. 29–32 μ, cum proc. 33–38·5 μ; lat. cum proc. 31–34 μ, sine proc. circ. 13–15 μ; lat. isthm. 6·5 μ.

Hab. With the preceding species.

This variety is readily distinguished from the typical form by the somewhat different form of the semicells and the peculiar nature of the processes. The latter are nodulose on the lower surface and on the lateral margins, but quite plane on their upper surface, and they are entirely devoid of rings of granules or denticulations except at the apex. The vertical view of all the examples seen was six-radiate.

Staurastrum pseudozonatum, Borge (in Bih. K. Sv. Vet.-Akad. Handl. xxiv. Afd. 3, no. 12, 1899, p. 30, t. 2. fig. 47), and *S. asteroideum*, West & G. S. West, are similar species of somewhat the same nature.

239. Staurastrum asteroideum, West & G. S. West, in Trans. Linn. Soc., ser. 2, Bot. v. 1896, p. 263, t. 17. fig. 5.

Forma processibus validis et paullo brevioribus. Long. 21 μ; lat. cum proc. 25 μ; lat. isthm. 6 μ.

Hab. Paddyfield between Kosgoda and Urahaighasmahendai.

240. Staurastrum pinnatum, W. B. Turn. in K. Sv. Vet.-Akad. Handl. xxv. 1893, no. 5, p. 115, t. 13. fig. 27.

Var. subpinnatum, nob. *Staurastrum subpinnatum*, Schmidle, in Flora, lxxxii. 1896, p. 311, t. 9. fig. 20.

Long. 30 μ; lat. sine proc. 15 μ, cum proc. 34–40 μ; lat. isthm. 8·5 μ. (Pl. 21. fig. 33.)

Hab. Paddyfields, Heneratgodha.

Turner's figures of *S. pinnatum* are very indistinct and inaccurate. Schmidle says his *S. subpinnatum* is primarily distinguished "das nur oberhalb am Grunde jedes der sechs radialen Arme je zwei Kurze abgestutzte Prominenten sich befinden"; but this applies equally well to *S. pinnatum*, as Turner says in his description "apicibus (apud basin processuum) 12 pinnatis, pinnis crenato-emarginatis." Turner distinctly shows these twelve emarginate verrucæ as arising above the bases of the processes in his figure of the vertical view (t. 13. fig. 27 *b*); his oblique figure (fig. 27 *c*), in which he shows the verrucæ as arising beneath the bases of the processes, is quite wrong. He falls into the same error in his figure of *S. pinnatum*, var. *simplex* (t. 13. fig. 29 *b*). His figure of the front view of *S. pinnatum* is wholly inaccurate and almost worthless.

Schmidle's *S. subpinnatum* only differs from *S. pinnatum* in the smooth basal region of the semicells possessing a basal ring of granules, and in the ring of twelve granules at the apices of the semicells. Our specimens also possessed these peculiarities, but they are not sufficient to separate the plant as a distinct species from *S. pinnatum*.

The length of the processes of *S. pinnatum*, var. *subpinnatum*, varies very much, and also the number of rings of denticulations on each process varies from about two to four or five.

241. STAURASTRUM TORSUM, W. B. Turn. in K. Sv. Vet.-Akad. Handl. xxv. 1893, no. 5, p. 115, t. 13. fig. 28.

Long. 26·5 μ; lat. sine proc. circ. 15 μ, cum proc. 36 μ; lat. isthm. 7 μ.

Hab. With the preceding species.

The forms we have observed of this species are somewhat different from the figures given by Turner. The characters of this plant are so well-marked that, allowing for the similar misrepresentation of position and lack of detail shown in many of his other figures, we feel sure that our plants are the same as those he describes as "common" in Bengal.

The three short processes on the lateral margins of each of the primary processes (two on the convex margin and one on the concave margin) were truncate and bidenticulate. The processes in front view were subparallel and slightly divergent. The minute granules at the apex of the semicells are in five pairs, one pair within the margin between the bases of each of the five processes.

242. STAURASTRUM ACANTHASTRUM, sp. n. (Pl. 22. fig. 1.) *S.* mediocre, circiter 2½-plo latius quam longum (cum processibus), modice constrictum; semicellulæ subglobosæ, lateribus in processus longos horizontaliter dispositos productis, processus spinis brevibus irregulariter ordinatis instructis, apicibus processuum profunde trifurcatis, apicibus semicellularum convexis papilla conica ad basin processus uniuscujusque; a vertice visæ 6-radiatæ, corpore parvo, processibus cum spinis brevibus distincte irregulariter ordinatis instructis, cum annulo papillorum 6, papilla singula ad basin processus uniuscujusque.

Long. 24 μ; lat. sine proc. 14 μ, cum proc. 63 μ; lat. isthm. 9 μ.

Hab. Paddyfields, Heneratgodha.

This species belongs to a group which includes *S. Rotula*, Nordst., *S. coronulatum*, Wolle, and *S. pentacladum*, Wolle. From the two former it is distinguished by its smaller size, its relatively much smaller body, and by the curiously ornamented processes. From *S. pentacladum* it is distinguished by its extraordinary processes and by the ring of conical papillæ at the apices of the semicells.

We know of only one *Staurastrum*—viz., *S. aspinosum*, Wolle—which possesses spines irregularly disposed at intervals along its processes.

243. STAURASTRUM CEYLANICUM, sp. n. (Pl. 22. fig. 2.) *S.* parvum, circiter 1⅓-plo latius quam longum (cum processibus), modice constrictum; semicellulæ late campanulatæ, apicibus leviter elevatis et convexis, angulis superioribus in processus breves glabros subhorizontaliter (vel leviter extrorsum) dispositos productis, apicibus processuum 4-denticulatis, juxta et infra apicem processus uniuscujusque verruca elevata tridenticulata instructa; a vertice visæ 5–6-gonæ, angulis in processus breves productis, lateribus concavis, apicibus processuum subdivisis denticulatis, ad basin processuum utrobique denticulo instructæ.

Long. 23 μ; lat. cum proc. 28·5–31 μ, sine proc. circ. 11·5 μ; lat. isthm. 4·5 μ.

Hab. Paddyfields, Heneratgodha.

The remarkable nature of the processes of this *Staurastrum* readily distinguishes it from any other.

244. STAURASTRUM ACESTROPHORUM, sp. n. (Pl. 22. fig. 3.) *S.* parvum, circiter $1\frac{1}{3}$-plo latius quam longum (cum processibus), modice constrictum; semicellulæ late campanulatæ, apicibus convexis, angulis superioribus in processus breves tenues horizontaliter dispositos productis, apicibus processuum 4-spinatis, margine superiore processus uniuscujusque verruca bispinata instructo, margine laterali sub processu unoquoque spina singula prædito; a vertice visæ triangulares, angulis in processus breves productis, apicibus processuum 4-spinatis, processibus cum spina singula utrobique, lateribus leviter concavis denticulis distantibus duobus instructis.

Long. cum spin. 23–25 μ, sine spin. 17·5 μ; lat. 25–27 μ; lat. isthm. 5 μ.

Hab. Paddyfields, Heneratgodha.

245. STAURASTRUM CERASTES, Lund. in Nov. Act. Soc. Scient. Upsala, ser. 3, viii. 1871, p. 69, t. 4. fig. 6.

Var. CEYLANICUM, var. n. (Pl. 22. fig. 4.) Var. minor, verrucis emarginatis cum denticulis ornatis, dente parvo infra basin processuum uniuscujusque, basi semicellularum truncato-inflata.

Long. 38 μ; lat. cum proc. 41 μ; lat. bas. semicell. 12·5 μ; lat. isthm. 8 μ.

Hab. With the preceding species.

246. STAURASTRUM APPROXIMATUM, sp. n. (Pl. 22. fig. 5.) *S.* parvum, circiter $1\frac{1}{2}$-plo latius quam longum (cum processibus), modice constrictum; semicellulæ subcampanulatæ, angulis superioribus in processus longos valde convergentes attenuatos delicatissime denticulatos productis, denticulis infra basin processuum majoribus, apicibus processuum tridenticulatis, apicibus semicellularum leviter convexis, serie verrucarum emarginatarum ornatis, ad basin semicellularum verruca emarginata sub processu unoquoque; a vertice visæ triangulares, angulis in processus longos delicatos undulatos productis, intra marginem unumquemque serie verrucarum emarginatarum instructæ.

Long. 32·5 μ; lat. cum proc. 50 μ, sine proc. circ. 12 μ; lat. isthm. 5·5 μ; lat. bas. semicell. 10 μ.

Hab. Paddyfields, Heneratgodha.

This species may be compared with *S. involutum*, W. B. Turn. (in 'Naturalist,' Nov. 1893, p. 347; = *S. curvatum*, W. B. Turn., 1892), but differs in the form of the semicells and in the much longer and more gracefully incurved processes. The base of the semicells is also quite different and the processes are more delicately denticulate.

247. STAURASTRUM TRIFORCIPATUM, sp. n. (Pl. 22. fig. 6.) *S.* parvum, pæne duplo longius quam latum (sine processibus), leviter constrictum; semicellulæ late cuneatæ, apicibus subconcavis, angulis superioribus in processus longos graciles arcuatos et incurvatos productis, marginibus processuum delicatissime undulatis et

apicibus truncato-obtusis; a vertice visæ triangulares, lateribus leviter concavis, angulis in processus longos graciles valde curvatos dextram versus (ut in *S. cyrtocero*) productis; processibus alterius semicellulæ cum iis alterius alternantibus et curvatis in directione opposita.

Long. 13 μ; lat. sine proc. 9 μ, cum. proc. 49 μ; lat. isthm. 5 μ.

Hab. Paddyfields, Heneratgodha.

The peculiar nature and the extraordinary curvature of the processes of this *Staurastrum* sufficiently distinguish it.

248. Staurastrum biordinatum, sp. n. (Pl. 21. fig. 36.) *S.* parvum, paullo latius quam longum (cum processibus), modice constrictum; semicellulæ latissime cyathiformes, ad basin rotundo-bulbosæ annulatim plicatæ, angulis superioribus in processus breves validos leviter inflexos productis ex basi latissima, processibus sparse denticulatis apicibus truncato-emarginatis, apicibus semicellularum convexis verrucis spinulato-emarginatis 6 præditis; a vertice visæ triangulares, lateribus concavis, angulis in processus breves emarginato-truncatos productis, verrucis emarginatis 4 ad marginem unumquemque et verrucis spinulato-emarginatis 6 intra marginem unumquemque (maximis in medio).

Long. 27 μ; lat. 32·5–34 μ; lat. isthm. 10 μ.

Hab. In stream, Victoria Park, Colombo.

249. Staurastrum polymorphum, Bréb. in Ralfs, Brit. Desm. 1848, p. 135, t. 22. fig. 9, t. 34. fig. 6.

Long. 21 μ; lat. cum proc. 22 μ; lat. isthm. 6 μ.

Hab. On rocks, Mahawelli Ganga.

Forma cum annulo granulorum parvorum circa basin ad *S. basidentatum*, Borge, accedens, sed minor. Long. 20 μ; lat. cum proc. 22 μ; lat. isthm. 6 μ.

Hab. Paddyfield between Kosgoda and Urahaighasmahendai.

250. Staurastrum iotanum, Wolle, 1884; Desm. U.S. p. 137, t. 51. figs. 5–7; West & G. S. West, in Journ. Linn. Soc., Bot. xxxiii. 1898, p. 315, t. 18. figs. 14, 15.

Hab. Paddyfields, Heneratgodha.

251. Staurastrum tetracerum, Ralfs, 1845; Brit. Desm. 1848, p. 137, t. 23. fig. 7.

Hab. With the preceding species.

252. Staurastrum pseudotetracerum, West & G. S. West, in Trans. Linn. Soc., ser. 2, Bot. v. 1895, p. 79, t. 8. fig. 39. *S. contortum*, Delponte, var. *pseudotetracerum*, Nordst. in K. Sv. Vet.-Akad. Handl. xxii. 1888, no. 8, p. 50, t. 5. fig. 14.

Long. sine proc. 13 μ, cum proc. 19–23 μ; lat. cum proc. 19–21 μ; lat. isthm. 5·8 μ.

Hab. With the preceding species.

253. **STAURASTRUM SUBGRACILLIMUM**, West & G. S. West, in Trans. Linn. Soc., ser. 2, Bot. v. 1896, p. 263, t. 17. fig. 34.

Forma processibus brevioribus, leviter curvatis. Long. 15 μ; lat. sine proc. 11·5 μ, cum proc. 40 μ; lat. isthm. 6 μ.

Hab. With the preceding species.

The specimens observed from Ceylon differed chiefly from the N.-American ones in the shorter processes.

254. **STAURASTRUM SUBPARVULUM**, sp. n. (Pl. 22. fig. 7.) *S.* parvum, circiter 1$\frac{1}{4}$-plo longius quam latum (sine processibus), modice constrictum, sinu aperto; semicellulæ subrectangulares, apicibus concavis, angulis inferioribus cum spina minuta, angulis superioribus in processus longos tenues subdivergentes minutissime nodulosos productis, apicibus processuum levissime dilatatis et minute tridenticulatis; a vertice visæ late ellipticæ, polis in processus longos subsigmoideos productis.

Long. sine proc. 10 μ; lat. sine proc. 9 μ, cum proc. 51 μ; lat. isthm. 4·2 μ; crass. 7 μ.

Hab. Paddyfields, Heneratgodha.

This species is unquestionably nearest to *S. parvulum*, West & G. S. West (*l. c.* p. 263, t. 17. fig. 1), but differs in its much longer processes, which are outwardly curved, and also in the form of its vertical view.

255. **STAURASTRUM COLUMBETOIDES**, sp. n. (Pl. 22. figs. 8, 9.) *S.* parvum, circiter 1$\frac{1}{4}$-plo longius quam latum (sine processibus), profunde constrictum, sinu sublineari; semicellulæ late truncato-pyramidatæ (ut in *Cosmario nitidulo*), angulis inferioribus subrotundatis, lateribus et apicibus subrectis, angulis superioribus in processus longissimos tenuissimos valde divergentos flexuosos delicate nodulosos productis, apicibus processuum bifurcatis; corpus semicellularum a vertice visum rotundo-rhomboideum, a latere visum rotundo-pyramidatum.

Long. sine proc. 14·5–17 μ, cum proc. 63–71·5 μ; lat. sine proc. 13–14 μ; lat. isthm. 5-5·5 μ; crass. 13 μ.

Hab. Paddyfields, Heneratgodha.

We know of nothing approaching this peculiar *Staurastrum*, with the body of a *Cosmarium* and the extraordinary diverging processes.

256. **STAURASTRUM EXCAVATUM**, West & G. S. West, *l. c.* 1895, p. 78, t. 8. fig. 42.

Long. 18·5 μ; lat. sine proc. 11 μ, cum proc. 53 μ; lat. isthm. 4·2 μ; crass. 6·7 μ.

Hab. With the preceding species.

257. **STAURASTRUM INDENTATUM**, sp. n. (Pl. 22. figs. 10–12.) (=*S. Pseudosebaldi*, Wille, var. *bicorne*, Boldt, "forma cum centrali parte apicis non inciso-aspera," W. B. Turn. in K. Sv. Vet.-Akad. Handl. xxv. 1893, no. 5, p. 123, t. 14. fig. 14.) *S.* subparvum, circiter 1$\frac{1}{2}$-plo latius quam longum (cum processibus), subprofunde constrictum; semicellulæ obcuneatæ, subinflatæ, ad basin cum denticulo utrobique, marginibus lateralibus verrucis emarginatis 2 ornatis, angulis superioribus in processus longos leviter et gracillime incurvatos productis, marginibus processuum

minute nodulosis, apicibus processuum distincte sed leviter bifurcatis, apicibus semicellularum leviter convexis (vel subrectis) cum verrucis depressis denticulatis ornatis, ad marginem superiorem in parte proxima processuum verrucis emarginatis 1–2; a vertice visæ subglobosæ, lateribus valde incrassatis, polis in processus longos rectos undulato-nodulosos productis, cum serie verrucarum bi- vel tridenticularum intra marginem lateralem unumquemque.

Long. 34–39 μ; lat. cum proc. 52–76 μ; lat. isthm. 6–8 μ; crass. 17 μ.

Hab. Paddyfields, Heneratgodha.

This species was observed in abundance, and is undoubtedly identical with the figure given by Turner of *S. Pseudosebaldi*, var. *bicorne*, forma. Turner's figure, which is copied from one of G. C. Wallich's drawings under a magnification of 330 diameters, lacks much detail; but the proportion, the curvature of the processes, and the general outline of the plant are such as to render positive its complete identity with *S. indentatum*. Turner describes the central part of the apex as "non inciso-aspera," and this portion of the front view of the plant has been represented by Wallich as a straight line. This we can quite imagine under a magnification of 330 diameters, as it is not until the plant is examined under a magnification of at least 500 diameters that the nature of the apex is apparent. It is then seen to consist of a series of flattened warts ornamented with minute teeth. These warts are seen much better in the vertical view, and are represented to a certain extent in the tilted view given by Wallich (*cf.* Turner, in K. Sv. Vet.-Akad. Handl. xxv. 1893, no. 5, t. 14. fig. 14 *b*).

S. indentatum possesses very little in common with *S. Pseudosebaldi*, var. *bicorne*, Boldt (in Öfvers. K. Vet.-Akad. Förh. 1885, no. 2, p. 117, t. 6. fig. 36); the basal portion of the semicells is much narrower and ornamented with warts, the apex exhibits in front view quite a different character, and the graceful curvature of the processes causes the general aspect of the *Staurastrum* to appear totally different.

258. STAURASTRUM SUBSALTANS, sp. n. (Pl. 22. fig. 15.) *S.* subparvum, circiter $1\frac{1}{2}$-plo latius quam longum (cum processibus), profunde constrictum; semicellulæ obcuneatæ, marginibus lateralibus cum verrucis truncato-emarginatis magnis 2 ornatis, angulis superioribus in processus longos subrectos dentato-nodulosos horizontaliter dispositos productis, apicibus processuum bifurcatis, apicibus semicellularum elevatis et subtruncatis cum spina subhorizontaliter dispositis ad elevationem utrobique; a vertice visæ rhomboideo-globosæ, lateribus incrassatis, polis in processus longos rectos subundulatos productis, ad basin processus uniuscujusque intra marginem cum spinis distantibus subparallelis binis.

Long. 34 μ; lat. cum proc. 52–56 μ; lat. isthm. 6 μ; crass. 14 μ.

Hab. Paddyfields, Heneratgodha.

This species is most closely allied to *S. saltans*, Joshua, from which it is chiefly distinguished by the much smaller and narrower body, and by the prominent subtruncate warts on the lateral margins. The processes are almost straight and horizontal, and less markedly dentate than those of *S. saltans*; moreover, the pair of spines on each side of the apical elevation are shorter and are attached directly to the elevation in *S. subsaltans*,

whereas they are situated on special rounded knob-like eminences in *Staurastrum saltans.* The apices of the processes are also less prominently bifurcate than those of *S. saltans* and the lower spine is usually the longer.

259. STAURASTRUM SALTANS, Joshua, in Journ. Linn. Soc., Bot. xxi. 1886, p. 641, t. 23. fig. 21; W. B. Turn. in K. Sv. Vet.-Akad. Handl. xxv. 1893, no. 5, p. 122, t. 14. fig. 8.

Long. 36–39 μ; lat. cum proc. 52–78 μ; lat. isthm. 8·5–9·5 μ; crass. 14 μ. (Pl. 22. figs. 13, 14.)

Hab. With the preceding species.

The dorsal and ventral margins of the processes of this species (as seen in front view) are prominently toothed, but the lateral margins (as seen in vertical view) are comparatively smooth. Moreover, some of the teeth of the upper margin, near the base of the processes, are emarginate. There are two pairs of strong, horizontally placed spines attached to four rounded eminences on the apex of each semicell. At the base of each semicell and close to the isthmus is a ring of minute denticulations.

Burmese specimens of this species received from Joshua agree exactly with those from Ceylon, and as the figure given by Joshua is so very rough and inaccurate, we think it advisable to figure two of the examples from Ceylon. Turner's figures of Bengal specimens are almost more inaccurate than that of Joshua, and neither author has depicted the elegance of the processes of this species.

Considerable variation was noticed in the length of the processes, and the teeth of the short-armed forms were of the same size as those of the long-armed forms, but fewer in number.

"*S. saltans* forma," described and figured by Borge in Bih. till K. Sv. Vet.-Akad. Handl. xxiv. Afd. 3, 1899, no. 12, p. 29, t. 2. fig. 44, is a variety of *S. grallatorium*, Nordst. Apart from other characters, it has only *one pair of spines at the apex of each semicell,* and these are directed vertically, whereas *S. saltans* has *two pairs of spines at each apex* which are directed horizontally.

260. STAURASTRUM SUBMANFELDTII, sp. n. (Pl. 22. fig. 16.) *S.* mediocre, circiter $1\frac{1}{4}$-plo latius quam longum (cum processibus), modice constrictum; semicellulæ subcyathiformes, angulis superioribus in processus longos horizontaliter dispositos productis, marginibus superioribus et inferioribus processuum acutissime dentatis, ad basin processuum verrucis emarginatis præditis, apicibus processuum quadridentatis, apicibus semicellularum convexis et glabris, ad basin extremum semicellularum sub processu unoquoque verruca subemarginata instructis; a vertice visæ triangulares, lateribus concavis glabris, angulis in processus longos productis, marginibus processuum levissime undulatis, intra marginem unumquemque verrucis emarginatis 4 ornatis.

Long. 40 μ; lat. cum proc. 52 μ; lat. isthm. 11·5 μ.

Hab. Paddyfields, Heneratgodha. Paddyfield between Kosgoda and Urahaighasmahendai.

This plant is nearest to *S. Manfeldtii*, Delponte, but as it occurred in quantity and always retained its characters, we thought it advisable to regard it as a distinct species. It differs from Delponte's species in its relatively smaller body, in the prominent constriction above the base of the semicells, in the more acute dentation, and in the prominent smooth apex. The vertical view also differs in its concave sides and more graceful processes.

From *Staurastrum Pseudosebaldi*, Wille, it is easily distinguished by the nature of the processes, which possess very prominent teeth only on the upper and lower margins, thus appearing almost smooth in vertical view. The nature of the base of the semicells and other characters also distinguish it from *S. Pseudosebaldi*.

Var. ELEGANS, var. n. (Pl. **22.** fig. 17.) Var. minor, processibus longioribus.

Long. 38 μ; lat. cum proc. 59 μ; lat. isthm. 8·5 μ.

Hab. Paddyfield between Kosgoda and Urahaighasmahendai.

Compare with *S. longiradiatum*, West & G. S. West.

261. STAURASTRUM CYCLACANTHUM, sp. n. (Pl. **22.** fig. 18.) *S.* subparvum, $1\frac{2}{3}$-plo latius quam longum (cum processibus), modice constrictum; semicellulæ latissime obcuneatæ, angulis superioribus in processus longos leviter incurvatos productis, marginibus lateralibus semicellularum acute binodosis, marginibus inferioribus processuum dentibus acutis 4 instructis, marginibus superioribus processuum in parte proxima spinis profunde bifurcatis 2 et in parte distante dentibus acutis 2 munitis, apicibus processuum cum spinis parvis 4, apicibus semicellularum levissime convexis cum verrucis trispinatis (a fronte visæ 3–4 indistinctis), trans nodum basalem semicellularum cum annulo granulorum interrupto; a vertice visæ triangulares, lateribus glabris leviter concavis, angulis in processus longos subundulatos productis, in centro cum annulo verrucarum trispinatarum 6, ad basin processus uniuscujusque spinis bifurcatis 2.

Long. 30–31 μ; lat. cum proc. 44–53 μ; lat. isthm. 8 μ.

Hab. Paddyfields Heneratgodha.

After some consideration we have decided to describe this plant as a new species, as it retains its characters quite constantly, and does not agree in the arrangement of its spines, warts, &c. with any of the described species to which it is allied. Perhaps its nearest relative is *S. floriferum*, West & G. S. West (in Trans. Linn. Soc., ser. 2, Bot. v. 1896, p. 267, t. 18. fig. 1), a species which, up to the present, is only known from N. America. It differs from this plant, however, in the nodose lateral margins of the semicells and in the teeth on the inferior margins of the processes, as well as in the two prominent bifurcate spines on the basal portion of the superior margin of each process. The processes of *S. cyclacanthum* are incurved, whereas those of *S. floriferum* are straight, and the apices of the processes of the former are furnished with four short spines, whereas those of the latter are provided with only three spines; moreover, the node at the base of each semicell of *S. cyclacanthum* is provided with an interrupted ring of granules. Both these species agree in the possession of an apical ring of six warts, but in *S. cyclacanthum* each wart is furnished with three spines, whereas in *S. floriferum* these spines are reduced to mere denticulations.

Staurastrum bicoronatum, L. N. Johnson, is an allied species, but *S. cyclacanthum* is readily distinguished from it.

Another allied species is *S. Manfeldtii*, Delponte, which, however, is larger, and does not possess the binodose lateral margins, nor the apical ring of six trispinate warts; neither is it so broad in proportion to its length. The vertical view of *S. Mansfeldtii* has also a relatively much larger body.

S. cyclacanthum can also be compared with three Indian forms figured by Turner (in K. Sv. Vet.-Akad. Handl. xxv. 1893, no. 5) as *S. curvatum*, W. B. Turn. (*l. c.* p. 128, t. 16. fig. 9; since changed to *S. involutum*, W. B. Turn., *cf.* Naturalist, Nov. 1893, p. 347), *S. Manfeldtii*, Delponte, var. *bispinatum*, W. B. Turn. (*l. c.* t. 16. figs. 11, 12), and *S. burmense*, W. B. Turn. (*l. c.* t. 16. fig. 13). We think these three should all be placed as forms of *S. Manfeldtii*, Delponte, and they differ considerably from *S. cyclacanthum*, especially in vertical view.

S. Pseudosebaldi, Wille, is a somewhat similar species, but the nature and arrangement of the spines are totally different. Compare also with *S. galeatum*, W. B. Turn.

262. STAURASTRUM BICORONATUM, L. N. Johns. in Bull. Torr. Bot. Club, xxi. 1894, p. 290, t. 211. fig. 9.

Hab. Paddyfields, Heneratgodha. Paddyfield between Kosgoda and Urahaighasmahendai.

263. STAURASTRUM GALEATUM, W. B. Turn. *l. c.* 1893, p. 122, t. 14. figs. 3, 9, 10. *S. subprotractum*, Schmidle, in Engler's Bot. Jahrbüch. xxvi. 1898, p. 55, t. 4. fig. 3.

Long. 28·5 μ; lat. cum proc. 42 μ; lat. isthm. 7·5 μ. (Pl. 22. fig. 19.)

Hab. Paddyfields, Heneratgodha.

Turner's figures are a very bad representation of this species, especially the vertical view. It would appear from his drawings that it is hardly distinguishable from *S. saltans*, Joshua, whereas in reality it but little resembles that species. *S. subprotractum*, Schmidle, seems to us to be very near if not identical with this species, but Schmidle's figure is not good and lacks detail. The processes of *S. galeatum* are rougher on the upper than on the lower margin, a fact which was quite overlooked by Turner, although indicated by Schmidle in his figure of *S. subprotractum.* Our specimens also possessed a small tooth at the base of the underside of the processes, which is unrepresented in the figures of either Turner or Schmidle. We feel sure that Schmidle's *S. subprotractum* is the same species as the plant we have found from Ceylon, and we are also certain that our plant is the same as that described by Turner as *S. galeatum.*

264. STAURASTRUM LONGIRADIATUM, West & G. S. West, in Trans. Linn. Soc., ser. 2, Bot. v. 1896, p. 267, t. 17. fig. 23.

Hab. In artificial tank, Peradeniya.

265. STAURASTRUM GRACILE, Ralfs, 1845; Brit. Desm. 1848, p. 136, t. 22. fig. 12.

Long. 27 μ; lat. cum proc. 44 μ; lat. isthm. 5·5 μ.

Hab. In running water, Royal Botanical Gardens, Peradeniya.

Var. NANUM, Wille, in Vid.-Selsk. Forhandl. Christiania, 1880, no. 11, p. 46, t. 2. fig. 31.
Long. 19 μ; lat. cum proc. 31 μ; lat. isthm. 4·8 μ.
Hab. Pond, Royal Botanical Gardens, and in artificial tank, Peradeniya.

Var. SUBORNATUM, Schmidle, in Engler's Bot. Jahrbüch. xxvi. 1898, p. 51, t. 4. fig. 1.
Long. 30 μ; lat. cum proc. 63 μ; lat. isthm. 9·5 μ.
Hab. In artificial tank, Peradeniya.

Var. ELEGANTULUM, var. n. (Pl. 22. fig. 20.) Var. minor, corpore angustiore; processibus leviter incurvatis, marginibus minutissime et acute nodulosis.
Long. 23 μ; lat. cum proc. 36 μ; lat. isthm. 4·4 μ.
Hab. In artificial tank, Peradeniya.

266. STAURASTRUM TAUPHORUM, sp. n. (Pl. 22. figs. 23–25.) *S.* mediocre, circiter 1⅔-plo latius quam longum (cum processibus), modice constrictum; semicellulæ campanulatæ basin versus, sursum multe expansæ, apicibus latis et levissime concavis, angulis superioribus in processus longos horizontaliter dispositos productis, margine superiore processuum dentato cum dente maximo ad basin, margine inferiore leviter undulato, apicibus processuum quadridentatis; a vertice visæ triangulares, lateribus leviter concavis, angulis in processus longos productis, marginibus lateralibus processuum levissime undulatis; ad basin semicellularum sub processu magno unoquoque cum processu parvo glabro profunde et late bifurcato (**T**-forma), brachio unoquoque retrorsum curvato et bidenticulato.

Long. 49–56 μ; lat. cum proc. 73–96 μ; lat. sine proc. circ. 23–27 μ; lat. isthm. 7–7·5 μ.

Hab. Paddyfields, Heneratgodha.

The chief peculiarity of this extraordinary *Staurastrum* consists of the small processes situated at the base of the semicells immediately underneath the large spreading processes. These small processes are three in number, quite smooth, and are suddenly divided into two widely spreading, gracefully curved arms. Each arm is of uniform thickness with the main process, but a little longer, and the whole whorl is disposed in a horizontal plane. Numerous specimens were examined, and all possessed precisely the same characters.

The teeth on the upper margin of the large processes, which gradually diminish in size towards their apices, are also characteristic; and, in addition, few *Staurastra* are known with the apices of the processes quadridentate.

Genus ARTHRODESMUS, Ehrenb.

267. ARTHRODESMUS OCTOCORNIS, Ehrenb. Infus. 1838, p. 152; Archer, in Pritch. Infus. ed. 4, 1861, p. 736, t. 1. fig. 30. *Xanthidium? octocorne*, Ralfs, Brit. Desm. 1848, p. 116, t. 20. fig. 2 *a–e*.
Hab. Paddyfields, Heneratgodha.

268. ARTHRODESMUS PHIMUS, W. B. Turn. in K. Sv. Vet.-Akad. Handl. xxv. 1893, no. 5, p. 136, t. 12. fig. 9.

Long. (sine spin.) 19·5 μ; lat. sine spin. 24–25·5 μ, cum spin. 29–31 μ. (Pl. 22. fig. 21.)

Hab. With the preceding species.

The forms we observed of this plant were rather more deeply constricted, the sinus being somewhat acuminate. They were also relatively a little broader.

269. ARTHRODESMUS CURVATUS, W. B. Turn. *l. c.* p. 135, t. 11. fig. 33, t. 12. figs. 2, 8.

Long. 37 μ; lat. sine spin. 37 μ, cum spin. 81–83 μ; lat. isthm. 11·5 μ.

Hab. With the preceding species.

270. ARTHRODESMUS GIBBERULUS, Joshua, in Journ. Linn. Soc., Bot. xxi. 1886, p. 34, t. 24. fig. 6.

Long. 31 μ; lat. sine spin. 28–30 μ, cum spin. 40–48 μ; lat. isthm. 8 μ; crass. 19 μ.

Hab. With the preceding species.

This species has previously been recorded from Burmah and Central India, and as the figures given by Joshua and Turner are very poor, we give an illustration of one of the examples we observed from Ceylon (Pl. 22. fig. 22). Neither of these authors has mentioned the thickening in the middle of the semicells which is well seen in vertical view. There is also a slight thickening or even sometimes almost a small excavation in the middle of the apex of the semicells.

Wildeman has united this plant and *A. curvatus*, W. B. Turn., under one species as *A. gibberulus*, clearly indicating that he has not seen the plants themselves.

271. ARTHRODESMUS INCUS, Hass., 1845; Ralfs, Brit. Desm. 1848, p. 118, t. 20. figs. 4 *a–d*.

Var. VALIDUS, West & G. S. West, in Journ. Linn. Soc. xxxiii. 1898, p. 320, t. 17. fig. 16.

Long. sine spin. 33 μ, cum spin. 84 μ; lat. sine spin. 29 μ, cum spin. 50 μ; lat. isthm. 9 μ.

Hab. With the preceding species.

Genus ONYCHONEMA, G. C. Wallich.

272. ONYCHONEMA UNCINATUM, G. C. Wallich, in Ann. & Mag. Nat. Hist. ser. 3, v. 1860, p. 195, t. 8. figs. 7–11.

Var. SUBGLABRUM, var. n. (Pl. 22. fig. 31.) Var. granulis intra margines superiores et laterales nullis.

Long. 19–20 μ; lat. cum spin. 32·5–34·5 μ; lat. isthm. 6–7 μ.

Hab. Paddyfields, Heneratgodha.

273. ONYCHONEMA LÆVE, Nordst. in Vidensk. Medd. naturh. Foren. Kjöbenhavn, 1869, no. 14, p. 206, t. 3. fig. 34.

Hab. Paddyfields, Heneratgodha. Paddyfield between Kosgoda and Urahaighasmahendai.

Genus SPHÆROZOSMA, Corda.

274. SPHÆROZOSMA GRANULATUM, Roy & Biss. in Journ. Bot. xxiv. 1886, p. 242, t. 268. fig. 7.

Hab. Paddyfields, Heneratgodha.

Var. PERGRANULATUM, var. n. (Pl. 22. fig. 28.) Var. semicellulis ellipticis (non oblongis); granulis numerosis, ad marginem lateralem unumquemque 3–4 et trans semicellulas 8–10 subirregulariter dispositis.

Long. 10·8–12 μ; lat. 10·8–11·5 μ; lat. isthm. 4·5–5 μ.

Hab. With the typical form.

Genus DESMIDIUM, Ag.

275. DESMIDIUM APTOGONUM, Bréb., 1836; Rabenh. Flor. Europ. Algar. iii. p. 154.

Hab. Paddyfields, Heneratgodha. Paddyfield between Kosgoda and Urahaighasmahendai.

Var. TETRAGONUM. *Aptogonum tetragonum,* Delponte, in Mem. Accad. Sci. Torino, ser. 2, xxx. 1878, p. 75, t. 3. figs. 20–23.

Hab. Paddyfield between Kosgoda and Urahaighasmahendai.

This variety was a true tetragonal form of *D. aptogonum,* and the filaments were twisted exactly as in the type. It was a very different plant from tetragonal forms of *D. Baileyi,* which were seen abundantly from Ceylon.

276. DESMIDIUM BAILEYI, De Bary, Conjug. p. 70. *Aptogonum Baileyi,* Ralfs, Brit. Desm. 1848, p. 208, t. 35. fig. 1. *D. Baileyi,* Nordst. in K. Sv. Vet.-Akad. Handl. xxviii. 1888, no. 8, p. 27, t. 2. figs. 4, 5.

Long. 17–19 μ; lat. 17–18 μ.

Hab. Paddyfields, Heneratgodha.

All the specimens observed were tetragonal.

277. DESMIDIUM PSEUDOSTREPTONEMA, sp. n. (Pl. 22. figs. 35–37.) *D.* mediocre, filis tortis, cum vagina mucosa; cellulæ subcompressæ, 1½–2-plo latiores quam longæ, profunde constrictæ, sinu angusto ad extremum gradatim subampliato; semicellulis transverse et anguste oblongis, lateribus rotundatis, apicibus subconvexis cum processibus connexis brevibus; a vertice visæ triangulatæ (vel bilobatæ), constrictione parva infra angulum unumquemque, angulis rotundo-angulatis, lateribus levissime convexis vel rectis.

Long. 17–21 μ; lat. 31–35 μ; lat. isthm. 13·5–19 μ; lat. apic. 14·5–15·5 μ.

Hab. Paddyfields, Heneratgodha.

This plant possesses a great similarity of appearance to *Spondylosium pulchrum*, Arch., especially the bilobed form. The short connecting processes on the apices of the semicells are, however, sufficient to readily distinguish it from that species. Moreover, the lateral lobes of the semicells are different from those of any form of *Spondylosium pulchrum* we have seen.

It also has a considerable resemblance to *Streptonema trilobum*, G. C. Wallich, but differs entirely in the nature of the connections between the cells, which are those of a true *Desmidium*. A gap of some considerable size is generally evident between the apices of any two contiguous cells. The filaments are enveloped in a thick mucous sheath.

278. DESMIDIUM CYLINDRICUM, Grev., 1827; Ralfs, in Ann. & Mag. Nat. Hist. v. 1843, p. 373, t. 8. fig. 1. *Didymoprium Grevillii*, Kuetz.; Ralfs, Brit. Desm. 1848, p. 57, t. 2.

Hab. Paddyfield between Kosgoda and Urahaighasmahendai.

279. DESMIDIUM GRACILICEPS, Lagerh. in Öfvers. af K. Vet.-Akad. Förh. 1885, no. 7, p. 228. *D. quadratum*, var. *graciliceps*, Nordst. in Wittr. & Nordst. Alg. Exsic. 1880, no. 367.

Long. 19–29 μ; lat. 19–27·5 μ; lat. apic. cell. 7·5–10 μ; lat. isthm. 14·5–19 μ; crass. 14–16 μ.

Hab. Paddyfields, Heneratgodha. Paddyfield between Kosgoda and Urahaighasmahendai.

280. DESMIDIUM COARCTATUM, Nordst. in Botaniska Notiser, 1887, p. 155; in K. Sv. Vet.-Akad. Handl. xxii. 1887, no. 8, p. 25, t. 2. fig. 3.

Hab. Paddyfield between Kosgoda and Urahaighasmahendai.

281. DESMIDIUM QUADRATUM, Nordst. in Act. Univ. Lund. ix. 1873, p. 49, t. 1. fig. 24.

Long. 13·5–16 μ; lat. 21–22 μ; lat. apic. 14·5–15 μ; crass. 20 μ.

Hab. Paddyfields, Heneratgodha.

A form with the cells relatively a little broader than in the type.

Genus GYMNOZYGA, Ehrenb.

282. GYMNOZYGA MONILIFORMIS, Ehrenb. in Bericht. Verh. Akad. Wissenschaft, Berlin, 1840, p. 212. *Didymoprium Borreri*, Ralfs, in Ann. & Mag. Nat. Hist. xvi. 1845, p. 10; Brit. Desm. 1848, p. 58, t. 3.

Var. GRACILESCENS, Nordst. in Bot. Notiser, 1880, p. 119; Wittr. & Nordst. Alg. Exsic. no. 367.

Hab. Paddyfields, Heneratgodha. Paddyfield between Kosgoda and Urahaighasmahendai.

Genus HYALOTHECA, Kuetz.

283. HYALOTHECA DISSILIENS, Bréb. in Ralfs, Brit. Desm. 1848, p. 51, t. 1. fig. 1. *Conferva dissiliens*, Dillw., 1806.

Hab. Paddyfields, Heneratgodha. Paddyfield between Kosgoda and Urahaighasmahendai.

Var. HIANS, Wolle, 1885; Freshw. Alg. U.S. 1887, p. 21, t. 54. figs. 14–16. *H. indica*, B. W. Turn. in K. Sv. Vet.-Akad. Handl. xxv. 1893, no. 5, t. 19. fig. 18.

Hab. Paddyfields, Heneratgodha.

284. HYALOTHECA INDICA, W. B. Turn. in K. Sv. Vet.-Akad. Handl. xxv. 1893, no. 5, p. 152, t. 22. fig. 17.

Long. 11–12·3 μ; lat. 9–9·5 μ.

Hab. Paddyfields, Heneratgodha.

The plants figured by Turner under the name of *H. indica* include two distinct species; that on t. 22. fig. 17 is truly a distinct species (*H. indica*), but that on t. 19. fig. 18 is merely a form of *H. dissiliens*, var. *hians*, Wolle.

285. HYALOTHECA MUCOSA, Ehrenb. in Bericht. Berlin, 1840, p. 212; Ralfs, Brit. Desm. 1848, p. 53, t. 1. fig. 2. *Conferva mucosa*, Dillw., 1809.

Var. MINOR, Roy & Biss. (Pl. **22.** fig. 26.)

Long. 12·5–14·5 μ; lat. 9·5–10·5 μ.

Hab. With the preceding species.

286. HYALOTHECA UNDULATA, Nordst. in Hedwigia, xviii. 1879, p. 74. *H. undulata*, var. *producta*, W. B. Turn. in K. Sv. Vet.-Akad. Handl. xxv. 1893, no. 5, p. 152, t. 18. fig. 15.

Forma major, cellulis paullo elongatis. Long. 20–24 μ; lat. 8·5 μ. (Pl. **22.** fig. 27.)

Hab. With the preceding species.

The specimens observed from Ceylon were larger than any European or American examples we have examined. The cells were also proportionately longer. *H. undulata*, var. *producta*, W. B. Turn., is identical with the typical form.

287. HYALOTHECA NEGLECTA, Racib. in Flora, lxxxi. Erg. 1895, p. 30, t. 3. figs. 2, 3; West & G. S. West, in Ann. Bot. xii. 1898, t. 4. figs. 22–33.

Hab. Paddyfields, Heneratgodha. Paddyfield between Kosgoda and Urahaighasmahendai.

Order *PROTOCOCCOIDEÆ.*

Family PALMELLACEÆ.

Subfamily CŒNOBIEÆ.

Genus CŒLASTRUM, Naeg.

288. CŒLASTRUM CUBICUM, Naeg. Gatt. einzell. Alg. p. 97, t. v.

Hab. In artificial tank, Peradeniya.

289. CŒLASTRUM PULCHRUM, Schmidle, in Berichte Deutsch. Bot. Gesellsch. x. 1892, p. 206, t. 11. fig. 1; Ber. nat. Gesellsch. zu Freiburg, vii. Heft 1, p. 12, t. 2. fig. 10.

Hab. Paddyfields, Heneratgodha. Paddyfield between Kosgoda and Urahaighasmahendai. Pond, Royal Botanical Gardens, Peradeniya.

Genus SORASTRUM, Kuetz.

290. SORASTRUM SPINULOSUM, Naeg. Gatt. einzell. Alg. 1849, p. 99, t. 5 D.

Hab. Paddyfields, Heneratgodha.

Genus PEDIASTRUM, Meyen.

291. PEDIASTRUM TETRAS, Ralfs, in Ann. & Mag. Nat. Hist. xiv. 1844, p. 469, t. 12. fig. 4. *Micrasterias Tetras*, Ehrenb., 1838.

Cœnob. 4, 1+7, 5+11.

Hab. Paddyfields, Heneratgodha. Paddyfield between Kosgoda and Urahaighasmahendai. Pool in glen by roadside, near Bandarawella (altit. 4000–5000 ft.). Muddy bottom of pool at foot of Hakgala Rock (altit. 6000 ft.). In artificial tank, Peradeniya.

292. PEDIASTRUM BORYANUM, Menegh. Synops. in Linnæa, xiv. 1840, p. 210; Ralfs, Brit. Desm. p. 187, t. 31. fig. 9 *a*.

Hab. In artificial tank, Peradeniya.

293. PEDIASTRUM DUPLEX, Meyen. *Pediastrum pertusum*, Kuetz. *P. Napoleonis*, Ralfs, Brit. Desm. p. 184, t. 31. fig. 7.

Hab. Paddyfields, Heneratgodha. In artificial tank, Peradeniya.

294. PEDIASTRUM CLATHRATUM, Lemmermann, in Plöner Forschungsberichten, 1899, p. 20. *P. enoplon*, West & G. S. West, 1895.

Hab. In artificial tank, Peradeniya.

Subfamily RHAPHIDIEÆ.

Genus SCENEDESMUS, Meyen.

295. SCENEDESMUS BIJUGATUS, Kuetz. *Achnanthes bijuga*, Turp. *Scenedesmus quadricauda*, Ralfs, var. *ecornis*, Ralfs.

Hab. Stream, Victoria Park, Colombo.

296. SCENEDESMUS OBLIQUUS, Kuetz. *Achnanthes obliqua*, Turp. *Scenedesmus acutus*, Meyen.

Hab. Paddyfields, Heneratgodha.

297. SCENEDESMUS DENTICULATUS, Lagerh. in Öfvers. af K. Vet.-Akad. Förh. 1882, no. 2, p. 61, t. 2. figs. 13–16.

Var. LINEARIS, Hansg. in Archiv Naturwiss. Landesdurchf. Böhm. vi. 1888, no. 6, p. 268.

Hab. Stream, Victoria Park, Colombo. Paddyfield between Kosgoda and Urahaighasmahendai. Muddy bottom of pool at foot of Hakgala Rock (altit. 6000 ft.). In artificial tank, Peradeniya.

298. SCENEDESMUS QUADRICAUDA, Bréb. Alg. Falaise, 1835, p. 66. *Achnanthes quadricauda*, 1828. *Scenedesmus caudatus*, Corda, 1838; Ralfs, Brit. Desm. p. 190, t. 31. figs. 12 *a–g*.

Hab. Paddyfields, Heneratgodha.

Var. ABUNDANS, Kirchn. Alg. Schles. p. 98.

Hab. Muddy bottom of pool at foot of Hakgala Rock (altit. 6000 ft.).

Var. MAXIMUS, West & G. S. West, in Trans. Linn. Soc., ser. 2, Bot. v. 1895, p. 83, t. 5. figs. 9, 10.

Long. cell. 29–30 μ; lat. cell. 9·5–11·5 μ.

Hab. In artificial tank, Peradeniya.

Var. OPOLIENSIS. (*Scenedesmus opoliensis*, P. Richter, 1895; Phycotheca Universalis, no. 686.)

Long. cell. 13–20 μ; lat. cell. 5–5·7 μ. (Pl. 17. figs. 16, 17.)

Hab. Paddyfields, Heneratgodha.

The number of small denticulations at the poles of the cells varied from one to three, and they were present on all the cells of the cœnobium.

Genus RHAPHIDIUM, Kuetz.

299. RHAPHIDIUM POLYMORPHUM, Fresen.; Rabenh. Flor. Europ. Algar. iii. p. 44.

Var. FALCATUM, Rabenh. Flor. Europ. Algar. iii. p. 45. *Micrasterias falcata*, Corda, 1835.

Hab. Paddyfields, Heneratgodha. Paddyfield between Kosgoda and Urahaighasmahendai.

Var. ACICULARE, Rabenh. *l. c.* p. 45. *Rhaphidium aciculare*, A. Br. *Ankistrodesmus acutissimus*, Arch.

Hab. Paddyfield between Kosgoda and Urahaighasmahendai. In artificial tank, Peradeniya.

Var. TURNERII, nob. *Rhaphidium ? spirale*, W. B. Turn. in K. Sv. Vet.-Akad. Handl. xxv. 1893, no. 5, p. 156, t. 20. fig. 26.

Crass. cell. 1·8–2 μ. (Pl. 17. fig. 18.)

Hab. Paddyfields, Heneratgodha.

The name "*spirale*" could not be adopted for the variety because there is already a well-marked var. *spirale* of this species (*cf.* West & G. S. West, in Journ. Bot. xxxvi. 1898, p. 335).

In var. *Turnerii* several cells occur in a colony, and are strongly twisted together in their central portions.

300. RHAPHIDIUM LONGISSIMUM, Schröder, in Bericht. Deutsch. Botan. Gesellsch. 1897, xv. p. 373, t. 17. fig. 4. *Closteriopsis longissima*, Lemmermann, in Plöner Forschungsberichten, t. 7. 1899, p. 29, t. 2. figs. 36–38. *Closterium pronum*, Bréb., var. *longissimum*, Lemm. (sec. Lemmermann).

Var. TROPICUM, var. n. Var. polis acutissimis sed non setiformibus.

Long. 225–288 μ; lat. 6–7·5 μ.

Hab. Paddyfields, Heneratgodha.

We have already shown that *Closteriopsis longissima*, Lemm., was most probably a form of *Rhaphidium longissimum*, Schröder (*cf.* Journ. Bot. xxxviii. 1900, p. 298), and after examining these specimens from Ceylon we feel convinced that the two are identical. Moreover, we are also certain that they belong to the genus *Rhaphidium*.

DESMATRACTUM, gen. n.

Cellulæ minutæ, libere natantes, semper solitariæ, late fusiformes vel ellipticæ cum apicibus longe acuminatis, ad medium subito sed minute constrictæ. Chromatophora pyrenoide singulo prædita.

301. DESMATRACTUM PLICATUM, sp. unica. (Pl. 17. figs. 14, 15.) Cellulæ longitudinaliter costatæ (costis 8), a vertice visæ circulares cum nodulis acutis 8 in ambitu.

Long. cell. 16–17·3 μ; lat. cell. 6·5–7 μ; lat. constrict. 5·3–5·8 μ.

Hab. Paddyfields, Heneratgodha.

This genus most nearly approaches *Rhaphidium*, but is principally distinguished by the form of the cell and by the central constriction, which extends equally all round the median part of the cell.

Genus TETRAËDRON, Kuetz.

302. TETRAËDRON CRUCIATUM, nob. *Micrasterias cruciata*, G. C. Wallich, in Ann. & Mag. Nat. Hist. ser. 3, v. p. 281, t. 13. fig. 12. *Staurophanum cruciatum*, W. B. Turn. in K. Sv. Vet.-Akad. Handl. xxv. 1893, no. 5, p. 159, t. 20. figs. 20, 21.

Diam. 37–40 μ.

Hab. In artificial tank, Peradeniya.

303. TETRAËDRON CAUDATUM, Hansg. in Hedwigia, xxvii. 1888, p. 131. *Astericium caudatum*, Corda, 1839. *Polyedrium pentagonum*, Reinsch.

Forma INCISUM, Reinsch.

Hab. Pond, Royal Botanical Gardens, Peradeniya.

Subfamily TETRASPOREÆ.

Genus SCHIZOCHLAMYS, A. Br.

304. SCHIZOCHLAMYS GELATINOSA, A. Br. in Kuetz. Species Algar. p. 891; Cooke, Brit. Freshw. Alg. p. 11, t. 3. fig. 6.
Hab. Paddyfields, Heneratgodha.

Subfamily DICTYOSPHÆRIEÆ.

Genus INEFFIGIATA, West & G. S. West.

305. INEFFIGIATA NEGLECTA, West & G. S. West, in Journ. Micr. Soc. 1897, p. 503.
Hab. Paddyfields, Heneratgodha.

Subfamily GLŒOCYSTIDÆ.

Genus OOCYSTIS, Naeg.

306. OOCYSTIS ELLIPTICA, West, in Journ. Micr. Soc. 1892, p. 736, t. 10. fig. 56.
Hab. Paddyfields, Heneratgodha. Paddyfield between Kosgoda and Urahaighasmahendai.

307. OOCYSTIS GIGAS, Archer, in Quart. Journ. Micr. Sci. 1877, p. 105; Cooke, Brit. Freshw. Alg. p. 26; West, in Journ. Micr. Soc. 1894, p. 14.

Var. INCRASSATA, West, *l. c.* p. 14, t. 2. fig. 37.
Hab. In artificial tank, Peradeniya.

Genus NEPHROCYTIUM, Naeg.

308. NEPHROCYTIUM NÄGELII, Grun. in Rabenh. Flor. Europ. Algar. iii. p. 52.
Hab. Paddyfields, Heneratgodha.

Genus GLŒOCYSTIS, Naeg.

309. GLŒOCYSTIS VESICULOSA, Naeg. Gatt. einzell. Alg. p. 66, t. 4 F.
Hab. Pond, Victoria Park, Colombo. Paddyfields, Heneratgodha. Paddyfield between Kosgoda and Urahaighasmahendai. Pond, Royal Botanical Gardens, Peradeniya. In artificial tank, Peradeniya.

310. GLŒOCYSTIS GIGAS, Lagerh. in Öfvers. af K. Vet.-Akad. Förh. 1883, no. 2, p. 63.
Protococcus gigas, Kuetz. *Glœocystis ampla*, Rabenh. Flor. Europ. Algar. iii. p. 29.
Hab. In artificial tank, and in running water, Royal Botanical Gardens, Peradeniya.

Subfamily PROTOCOCCACEÆ.

Genus PLEUROCOCCUS, Menegh.

311. PLEUROCOCCUS VULGARIS, Menegh.; Rabenh. Flor. Europ. Algar. iii. p. 24.
Hab. On decomposing surface of gneiss, Matava.

Genus TROCHISCIA, Kuetz.

312. TROCHISCIA ACICULIFERA, Hansg. in Hedwigia, xxvii. 1888, p. 129. *Acanthococcus aciculifera*, Lagerh.
Hab. Stream, Victoria Park, Colombo.

313. TROCHISCIA RETICULARIS, Hansg. *l. c.* p. 129. *Acanthococcus reticularis*, Reinsch.
Hab. Paddyfield between Kosgoda and Urahaighasmahendai.

Class **MYXOPHYCEÆ.**

Order *HORMOGONEÆ.*

Suborder HETEROCYSTEÆ.

Family RIVULARIACEÆ.

Genus CALOTHRIX, Agh.

314. CALOTHRIX JULIANA, Born. & Flah. in Ann. Sci. Nat. 7e série, Bot. iii. 1886, p. 348. *Lyngbya juliana*, Menegh., 1841.
Crass. fil. 13·5–15·5 μ; crass. trich. 9·5–11·5 μ.
Hab. In artificial tank, Peradeniya.

315. CALOTHRIX FUSCA, Born. & Flah. *l. c.* p. 364. *Mastichothrix fusca*, Kuetz. in Phyc. General. 1843, p. 232.
Hab. In pond, Royal Botanical Gardens, Peradeniya.

316. CALOTHRIX BREVIARTICULATA, West & G. S. West, in Journ. Bot. xxxv. 1897, p. 240.
Crass. fil. 8·5–13·5 μ; crass. trich. 7–7·5 μ.
Hab. Epiphytic on *Plectonema Wollei*, Farlow, in artificial tank, Peradeniya.

Family SIROSIPHONIACEÆ.

Genus Hapalosiphon, Naeg.

317. **Hapalosiphon luteolus**, West & G. S. West, in Journ. Bot. xxxv. 1897, p. 241.

Crass. fil. 7–11·5 μ; crass. cell. 5·5–7 μ; long. heterocyst. 7·6–14 μ; lat. heterocyst. 6–7·5 μ.

Hab. Paddyfield between Kosgoda and Urahaighasmahendai.

318. **Hapalosiphon delicatulus**, sp. n. *H.* inter alias algas aquaticas sparsus, flavo-æruginosus, filis flexuosis, vaginis tenuissimis, achrois, valde arctis; ramis singulis distantibus et unilateralibus, filo primario in crassitudine similibus vel paullo angustioribus; cellulis diametro 2–3½-plo longioribus, iis ramorum sæpe longioribus (diametro 11–30-plo longioribus); heterocystis intercalaribus, oblongis, diametro duplo vel triplo longioribus; sporis non visis.

Crass. fil. 3·8–4 μ; crass. ram. 3·2–3·5 μ; long. heterocyst. 7–12 μ; lat. heterocyst. 3–3·8 μ.

Hab. Paddyfields, Heneratgodha.

The nearest species to this is *H. intricatus*, West, but the Ceylon species is much more delicate, has a distinct habit, and differs in several other characters. The branches arise approximately at right angles to the primary filament, and the cell of the primary filament at the base of the branch always projects for some considerable distance into the delicate sheath of the latter. Some of the cells of the branches are very elongated and contain numerous small granules, but the cells of the primary filaments usually possess homogeneous cell-contents.

Genus Stigonema, Agh.

319. **Stigonema ocellatum**, Thur. in Ann. Sci. Nat. 6^e sér., Bot. i. 1875, p. 380. *Conferva ocellata*, Dillw. Brit. Conf. p. 60. *Sirosiphon ocellatus*, Kuetz.

Hab. Paddyfields, Heneratgodha.

320. **Stigonema panniforme**, Born. & Flah. in Ann. Sci. Nat. 7^e série, Bot. v. 1887, p. 71. *Scytonema panniforme*, Agh., 1817. *Sirosiphon panniformis*, Kuetz., 1843.

Crass. fil. 25–29 μ.

Hab. Forming tufts on stems of *Osbeckia buxifolia* on summit of Hakgala Rock (only in very exposed situations).

Genus Nostochopsis, Wood.

321. **Nostochopsis lobatus**, Wood, in Proc. Amer. Phil. Soc. Philadelphia, 1869, p. 127; in Smithson. Contrib. Knowl. 1874, iii. p. 45, t. 3. fig. 6; Born. & Flah.

in Ann. Sci. Nat. 7ᵉ sér., Bot. v. 1887, p. 80; Wille, in Bih. K. Sv. Vet.-Akad. Handl. viii. 1884, no. 18, t. 1. figs. 1–19; West & G. S. West, in Journ. Bot. xxxiv. 1896, p. 381, t. 361. figs. 1, 2.

Hab. Paddyfield between Kosgoda and Urahaighasmahendai. Small pond, Peradeniya.

Family SCYTONEMACEÆ.

Genus SCYTONEMA, Ag.

322. SCYTONEMA AMBIGUUM, Kuetz. Spec. Algar. 1849, p. 894; Tab. Phyc. ii. 1850–52, p. 7, t. 26. fig. 2; Born. & Flah. in Ann. Sci. Nat. 7ᵉ série, Bot. v. 1887, p. 100.

Hab. Paddyfields, Heneratgodha.

323. SCYTONEMA MIRABILE, Thuret. *Conferva mirabilis*, Dillw. *Scytonema figuratum*, Agh. Syst. Algar. 1824, p. 38.

Hab. With the preceding species.

Genus TOLYPOTHRIX, Kuetz.

324. TOLYPOTHRIX CRASSA, West & G. S. West, in Journ. Bot. xxxv. 1897, p. 267.

Crass. fil. 20–25 μ; crass. trich. 11–19 μ.

Hab. On bark, Royal Botanical Gardens, Peradeniya. Also on the sides of a well, Pandure.

325. TOLYPOTHRIX PHYLLOPHILA, West & G. S. West, *l. c.*

Crass. fil. 13·5–17 μ; crass. trich. 8·5–10 μ.

Hab. On bark, Royal Botanical Gardens, Peradeniya.

The sheaths of this form were lamellose and coloured brown, but the plants had been preserved in a mixture of glycerin and alcohol and in the same bottle were large pieces of bark and a quantity of a red species of *Trentepohlia*. It is highly probable that the sheaths of the *Tolypothrix* (which are normally colourless) had been dyed by colouring-matter extracted by the fluid from the other contents of the bottle.

326. TOLYPOTHRIX LANATA, Kuetz. Sp. Alg. p. 314; Born. & Flah. *l. c.* p. 120.

Hab. Pool in glen by roadside, near Bandarawella (altit. 4000–5000 ft.).

Family NOSTOCEÆ.

Genus NOSTOC, Vaucher.

327. NOSTOC MICROSCOPICUM, Carm.; Born. & Flah. *l. c.* p. 210. *Nostoc rupestre*, Kuetz.

Hab. Wet rocks, Kadaganuwa.

Genus CYLINDROSPERMUM, Kuetz.

328. CYLINDROSPERMUM TROPICUM, sp. n. *C.* filis natantibus in stagnis, trichomatibus pallide ærugineis, articulis cylindricis, diametro 2½–3-plo longioribus, ad geniculis constrictis; heterocystis articulis duplo crassioribus, late ellipticis; sporis maximis, oblongo-ellipticis, episporio papillato fuscescente.

Crass. trich. 3 μ; lat. heterocyst. 5·8–6·5 μ; long. heterocyst. 8 μ; long. spor. 42–43 μ; lat. spor. 19 μ.

Hab. Paddyfield between Kosgoda and Urahaighasmahendai.

This species is nearest to *C. majus*, Kuetz., especially in its papillate spores, but it is easily distinguished by the narrower trichomes, the much longer cells, and the large size of the spores.

Suborder HOMOCYSTEÆ.

Family VAGINARIEÆ.

Genus SCHIZOTHRIX, Kuetz.

329. SCHIZOTHRIX LARDACEA, Gomont, in Ann. Sci. Nat. 7^{e} série, Bot. xv. p. 311, t. 8. figs. 8, 9.

Hab. Paddyfields, Heneratgodha.

330. SCHIZOTHRIX DELICATISSIMA, West & G. S. West, in Journ. Bot. xxxv. 1897, p. 269.

Long. tot. fil. 153–200 μ; crass. fil. 5·5–6·5 μ; crass. trich. 0·7–0·9 μ.

Hab. Among *Stigonema panniforme* on summit of Hakgala Rock.

Genus DASYGLŒA, Thwaites.

331. DASYGLŒA AMORPHA, Thw. in Engl. Bot., Suppl. 1848, t. 2941; Kuetz. Spec. Algar. p. 272; Gomont, *l. c.* p. 347, t. 13. figs. 11, 12.

Crass. trich. 4·5–5·5 μ.

Hab. In artificial tank, Peradeniya.

Family LYNGBYEÆ.

Genus PLECTONEMA, Thuret.

332. PLECTONEMA WOLLEI, Farlow, in Bull. Bussey Instit. 1875, p. 77 (note); Gomont, *l. c.* xvi. p. 98, t. 1. fig. 1. *Lyngbya Wollei*, Farlow, 1876.

Crass. fil. 45–65 μ; crass. trich. 36–45 μ.

Hab. In large masses, in artificial tank, Peradeniya.

Genus LYNGBYA, Agh.

333. LYNGBYA MAJOR, Meneghini, 1837; Gomont, in Ann. Sci. Nat. 7e sér. xvi. 1892, p. 125, t. 3. fig. 15.

Crass. fil. 23–25 μ; crass. trich. 13·5–15·5 μ.

Hab. Small pond, Peradeniya.

334. LYNGBYA NIGRA, Agh., 1824; Gomont, *l. c.* p. 143, t. 3. fig. 16.

Hab. Mouth of river, Pandure.

335. LYNGBYA VERSICOLOR, Gomont, *l. c.* p. 147, t. 4. figs. 4, 5. *Phormidium versicolor*, Wartm.

Hab. In artificial tank, Peradeniya.

Genus PHORMIDIUM, Kuetz.

336. PHORMIDIUM LURIDUM, Gomont, *l. c.* p. 165, t. 4. figs. 17, 18. *Leptothrix lurida*, Kuetz., 1849.

Forma tenuior: crass. trich. 1·5 μ.

Hab. Shallow pool, mangrove-swamp, Pandure.

337. PHORMIDIUM VALDERIANUM, Gomont, *l. c.* p. 167, t. 4. fig. 20. *Leptothrix Valderiæ*, Delponte, 1857.

Hab. Muddy bottom of pool at foot of Hakgala Rock (altit. 6000 ft.).

Genus OSCILLATORIA, Vaucher.

338. OSCILLATORIA PRINCEPS, Vaucher, 1803; Gomont, *l. c.* p. 206, t. 6. fig. 9. *Oscillaria maxima*, Kuetz., 1843. *Oscillatoria imperator*, Wood, 1869.

Hab. Pond, Victoria Park, Colombo. Paddyfields, Heneratgodha.

339. OSCILLATORIA LIMOSA, Agh. Dispos. Algar. Sueciæ, 1812, p. 35. *Oscillaria Frœlichii*, Kuetz., 1843.

Hab. Small pond, Peradeniya.

340. OSCILLATORIA TENUIS, Agh., 1813; Gomont, *l. c.* p. 220, t. 7. figs. 2, 3.

Hab. Shallow pool, mangrove-swamp, Pandure.

341. OSCILLATORIA ACUMINATA, Gomont, *l. c.* p. 227, t. 7. fig. 12.

Forma cellulis subquadratis: crass. trich. 3·8 μ.

Hab. Mouth of river, Pandure.

342. OSCILLATORIA ANIMALIS, Agh., 1827; Gomont, *l. c.* p. 227, t. 7. fig. 13.

Hab. Paddyfields, Heneratgodha.

Genus Spirulina, Turpin.

343. Spirulina princeps, sp. n. Trichomata inter algas varias sparsa, in spirum laxiusculum regularem diametro 11–12 μ regulariter contorta, anfractis inter se 9·5 μ distantibus, æruginosa et homogenea.

Crass. trich. 4·5–5 μ.

Hab. Paddyfield between Kosgoda and Urahaighasmahendai.

This fine *Spirulina* is considerably larger than any previously described species. The trichomes are relatively short, and very regularly twisted through about eighteen turns.

Order *CHROOCOCCOIDEÆ.*

Family CHROOCOCCACEÆ.

Genus Chroococcus, Naeg.

344. Chroococcus turgidus, Naeg. Gatt. einzell. Alg. 1849, p. 46. *Protococcus turgidus*, Kuetz. Tab. Phyc. i. p. 5, t. 6.

Hab. Shallow pool, mangrove-swamp, Pandure. Paddyfields, Heneratgodha.

Genus Merismopedia, Meyen.

345. Merismopedia glauca, Naeg. *l. c.* p. 55, t. 1 d. fig. 1. *Gonium glaucum*, Ehrenb.

Hab. Among *Spirogyra* sp. in fast-running stream, Peradeniya. Mouth of river, Pandure. Shallow pool, mangrove-swamp, Pandure.

Genus Polycystis, Kuetz.

346. Polycystis æruginosa, Kuetz. Tab. Phyc. i. p. 7; Sp. Alg. p. 210. *Clathrocystis æruginosa*, Henfrey, in Micr. Journ. 1856, p. 53, t. 4. figs. 28–36; Rabenh. Flor. Europ. Algar. ii. p. 54.

Hab. Often very abundant on the surface of pond, Royal Botanical Gardens, Peradeniya.

Class **BACILLARIEÆ.**

Order *RHAPHIDIEÆ.*

Family CYMBELLEÆ.

Genus Cymbella, Agh.

347. Cymbella cuspidata, Kuetz. Bacill. p. 79, t. 3. fig. 40.

Hab. Muddy bottom of pool at foot of Hakgala Rock (altit. 6000 ft.).

348. Cymbella cymbiformis, Bréb. Alg. Falaise, p. 49, t. 7. *Cocconema cymbiforme*, Ehrenb.

Hab. In stream, Peradeniya. Pond, Victoria Park, Colombo. Wet rocks, Kadaganuwa.

Genus ENCYONEMA, Kuetz.

349. ENCYONEMA GRACILE, Rabenh. Süssw. Diat. p. 25, t. 10.
Hab. Pond, Royal Botanical Gardens, Peradeniya.

Family NAVICULEÆ.

Genus STAURONEIS, Ehrenb.

350. STAURONEIS PHŒNICENTERON, Ehrenb. Verbreit. v. fig. 1.
Hab. Paddyfields, Heneratgodha.

Genus NAVICULA, Bory.

351. NAVICULA MAJOR, Kuetz. Bacill. p. 97, t. 4. fig. 19.
Hab. Paddyfields, Heneratgodha.

352. NAVICULA VIRIDIS, Kuetz. *l. c.* p. 97, t. 4. fig. 18.
Hab. Paddyfields, Heneratgodha. Rocks in Mahawelli Ganga. Muddy bottom of pool at foot of Hakgala Rock (altit. 6000 ft.).

353. NAVICULA GIBBA, Kuetz. *l. c.* p. 98, t. 28. fig. 70.
Hab. Paddyfields, Heneratgodha. Paddyfield between Kosgoda and Urahaighasmahendai. Muddy bottom of pool at foot of Hakgala Rock (altit. 6000 ft.).

354. NAVICULA BICAPITATA, Lagerstedt, Diat. Spetsb. 1873, p. 23, t. 1. fig. 5.
Hab. In artificial tank, Peradeniya.

355. NAVICULA APPENDICULATA, Kuetz. Bacill. p. 93, t. 3. fig. 28.
Hab. Muddy bottom of pool at foot of Hakgala Rock (altit. 6000 ft.).

356. NAVICULA GRACILIS, Kuetz. *l. c.* p. 91, t. 3. fig. 48.
Hab. Running water, Royal Botanical Gardens, Peradeniya.

357. NAVICULA MARINA, Ralfs, in Pritch. Infus. ed. iv. 1861, p. 903.
Hab. Shallow pool, mangrove-swamp, Pandure.

358. NAVICULA CUSPIDATA, Kuetz. Bacill. p. 94, t. 3. figs. 24, 37.
Hab. In artificial tank, Peradeniya.

359. NAVICULA IRIDIS, Ehrenb. Verbreit. p. 130, t. 4. fig. 2. *N. firma*, W. Sm. Brit. Diat. i. p. 48, t. 16. fig. 138.
Hab. Muddy bottom of pool at foot of Hakgala Rock (altit. 6000 ft.).

Var. AMPHIRHYNCHUS, De Toni, Syll. Alg. ii. p. 154.
Hab. Paddyfields, Heneratgodha.

Genus VANHEURCKIA, Bréb.

360. VANHEURCKIA RHOMBOIDES, Bréb. Ess. Monogr. Vanh. p. 4, t. 3. fig. 15.
Hab. Paddyfield between Kosgoda and Urahaighasmahendai.

Var. SAXONICA, West & G. S. West.
Hab. Paddyfields, Heneratgodha. Stream, Victoria Park, Colombo. Paddyfields, Pandure.

Genus PLEUROSIGMA, W. Sm.

361. PLEUROSIGMA ACUMINATUM, Grun. in Abh. Zool.-bot. Ges. Wien, x. 1860, p. 561, t. 4. fig. 6.
Hab. Small pond, Peradeniya.

362. PLEUROSIGMA SPENCERII, W. Sm. in Ann. & Mag. Nat. Hist. ser. II. ix. 1852, p. 12, t. 2. fig. 15.
Hab. Shallow pool, mangrove-swamp, Pandure.

Family GOMPHONEMEÆ.

Genus GOMPHONEMA, Agh.

363. GOMPHONEMA TENELLUM, W. Sm. Brit. Diat. i. p. 80, t. 29.
Hab. Among *Spirogyra* sp., from fast-running stream, Peradeniya.

364. GOMPHONEMA GRACILE, Ehrenb. Infus. 1838, p. 217, t. 18. fig. 3.
Hab. Pond, Victoria Park, Colombo. Pond, Royal Botanical Gardens, Peradeniya. In artificial tank and in running water, Peradeniya.

Family ACHNANTHEÆ.

Genus ACHNANTHES, Bory.

365. ACHNANTHES LINEARIS, Grun. in Cleve & Grun. Arct. Diat. p. 23.
Hab. Pond, Royal Botanical Gardens, Peradeniya.

Genus COCCONEIS, Ehrenb.

366. COCCONEIS PLACENTULA, Ehrenb. Infus. p. 194.
Hab. Pond in glen by roadside, near Bandarawella (altit. 4000–5000 ft.).

Order *PSEUDO-RHAPHIDIEÆ.*

Family EPITHEMIEÆ.

Genus Epithemia, Bréb.

367. **Epithemia Sorex**, Kuetz. Bacill. p. 33, t. 3. fig. 12.
Hab. Pool in glen by roadside, near Bandarawella (altit. 4000–5000 ft.).

368. **Epithemia gibba**, Kuetz. *l. c.* p. 35, t. 4. fig. 22.
Hab. Paddyfield between Kosgoda and Urahaighasmahendai. Pool in glen by roadside, near Bandarawella (altit. 4000–5000 ft.). In artificial tank and in stream, Peradeniya.

369. **Epithemia Argus**, Kuetz. *l. c.* p. 34, t. 29. fig. 55.
Hab. Pool in glen by roadside, near Bandarawella (altit. 4000–5000 ft.).
In artificial tank, Peradeniya.

Genus Eunotia, Ehrenb.

370. **Eunotia major**, Rabenh., var. **bidens**, Van Heurck,. Syn. p. 142, t. 34. fig. 5.
Hab. Paddyfield between Kosgoda and Urahaighasmahendai.

371. **Eunotia gracilis**, Rabenh. Fl. Eur. Alg. i. p. 72.
Hab. Pond, Royal Botanical Gardens, Peradeniya.

372. **Eunotia pectinalis**, Rabenh. *l. c.* p. 73.
Hab. Muddy bottom of pool at foot of Hakgala Rock (altit. 6000 ft.). In artificial tank and in small pond, Peradeniya.

373. **Eunotia Veneris**, Kuetz. Bacill. p. 40, t. 30. fig. 7. *E. incisa,* Greg. in Journ. Micr. Sci. ii. (1854) p. 96, t. 4. fig. 4.
Hab. Paddyfield between Kosgoda and Urahaighasmahendai. Pond, Royal Botanical Gardens, Peradeniya.

374. **Eunotia tetraodon**, Ehrenb. Infus. p. 192, t. 21. fig. 25.
Hab. Paddyfields, Heneratgodha.

375. **Eunotia lunaris**, Grun. in Van Heurck, Syn. p. 144, t. 35. figs. 3–4, 6. *Synedra lunaris,* Ehrenb. in Abh. Berl. Akad. 1831, p. 87.
Hab. Stream, Victoria Park, Colombo.

376. **Eunotia flexuosa**, Kuetz., var. **bicapitata**, Grun. in Van Heurck, Syn. p. 145, t. 35. fig. 11. *Synedra biceps,* W. Sm.
Hab. Pond, Victoria Park, Colombo. Paddyfields, Heneratgodha. Paddyfield between Kosgoda and Urahaighasmahendai.

Genus Actinella, Lewis.

377. Actinella punctata, Lewis, in Proc. Acad. Philad. 1863 (1864), p. 343. *Gonatozygon sexspiniferum*, W. B. Turner.

Hab. Pond, Royal Botanical Gardens, Peradeniya.

Exactly like specimens we have examined from Malaga, New Jersey, U.S.A.

Genus Desmogonium, Ehrenb.

378. Desmogonium Rabenhorstianum, Grun. Diat. Ins. Bangka, p. 6, t. 1. fig. 1.

Hab. Paddyfields, Heneratgodha.

This was abundant, and precisely like numerous specimens we have examined from Dominica, W. Indies.

Family SYNEDREÆ.

Genus Synedra, Ehrenb.

379. Synedra pulchella, Kuetz. Bacill. p. 68, t. 29. fig. 37.

Hab. Among *Spirogyra* sp. in fast-running stream, Peradeniya. Pool in glen by roadside, near Bandarawella (altit. 4000–5000 ft.).

380. Synedra Ulna, Ehrenb. Infus. p. 211, t. 17. fig. 1.

Hab. Pond, Victoria Park, Colombo. Paddyfield between Kosgoda and Urahaighasmahendai. Among *Spirogyra* sp. in little muddy backwaters, Mahawelli Ganga. Pond, Royal Botanical Gardens, Peradeniya.

Var. subæqualis, Van Heurck, Syn. p. 151, t. 38. fig. 13.

Hab. Mahawelli Ganga.

381. Synedra Acus, Kuetz. Bacill. p. 68, t. 15. fig. 7.

Hab. In running water, Royal Botanical Gardens, Peradeniya.

382. Synedra radians, Kuetz. *l. c.* p. 54, t. 14. fig. vii. 1–4.

Hab. In artificial tank, Peradeniya.

Family FRAGILARIEÆ.

Genus Fragilaria, Lyngb.

383. Fragilaria virescens, Ralfs, in Ann. & Mag. Nat. Hist. ser. I. xii. (1843) p. 110, t. 2. fig. 6.

Hab. On wet rocks, Mahawelli Ganga.

384. Fragilaria capucina, Desmaz. ex Kuetz. Bacill. p. 45, t. 16. fig. 3.

Hab. Among Podostemons, Mahawelli Ganga.

Family TABELLARIEÆ.

Genus TABELLARIA, Ehrenb.

385. TABELLARIA FENESTRATA, Kuetz. Bacill. p. 127, t. 17. fig. 22.
Hab. In running water, Royal Botanical Gardens, Peradeniya.

Family SURIRELLIEÆ.

Genus SURIRELLA, Turp.

386. SURIRELLA ROBUSTA, Ehrenb., var. SPLENDIDA, Van Heurck, Syn. p. 187, t. 72. fig. 4.
Hab. Muddy bottom of pool at foot of Hakgala Rock (6000 ft.). In artificial tank, Peradeniya.

387. SURIRELLA OVALIS, Bréb., var. ANGUSTA, Van Heurck, *l. c.* p. 189, t. 73. fig. 12.
Hab. Muddy bottom of pool at foot of Hakgala Rock (6000 ft.).

Family NITZSCHIEÆ.

Genus NITZSCHIA, Hass.; emend. Grun.

388. NITZSCHIA CURVULA, W. Sm. Brit. Diat. ii. p. 89.
Hab. Paddyfield between Kosgoda and Urahaighasmahendai.

389. NITZSCHIA LINEARIS, W. Sm. *l. c.* i. p. 39, t. 13. fig. 10.
Hab. With the preceding species.

390. NITZSCHIA PALEA, W. Sm. *l. c.* ii. p. 89.
Hab. Muddy bottom of pool at foot of Hakgala Rock (altit. 6000 ft.).

391. NITZSCHIA OBTUSA, W. Sm. *l. c.* i. p. 39, t. 13. fig. 109.
Hab. Shallow pool, mangrove-swamp, Pandure.

392. NITZSCHIA LONGISSIMA, Ralfs, var. CLOSTERIUM. *Cf.* Van Heurck, Syn. Atlas, t. 70. fig. 8.
Hab. With the preceding species.

Order *CRYPTO-RHAPHIDIEÆ.*

Family MELOSIREÆ.

Genus MELOSIRA, Agh.

393. MELOSIRA ROSEANA, Rabenh. Süssw. Diat. p. 13, t. 10. Suppl. fig. 5.
Hab. Among *Trentepohlia* sp. on bark of trees, Peradeniya. On wet rocks, Kadaganuwa.

394. MELOSIRA GRANULATA, Ralfs, in Pritch. Infus. ed. iv. p. 820.
Hab. Shallow pool, mangrove-swamp, Pandure. In pond and in running water, Royal Botanical Gardens, Peradeniya. Also in artificial tank, Peradeniya.

Family BIDDULPHIEÆ.

Genus TERPSINOË, Ehrenb.

395. TERPSINOË MUSICA, Ehrenb. in Abh. Akad. Berl. 1841 (1843), p. 390, t. 3. sect. IV. fig. 1.

Hab. Pool in glen by roadside, near Bandarawella (altit. 4000–5000 ft.).

This interesting species was in considerable quantity. We have previously had it in abundance from both cold and warm streams from Dominica, W. Indies (*cf.* West & G. S. West, in Journ. Linn. Soc., Bot. xxxiv. 1899, p. 295).

Summary.

	Genera.	Species.
FLORIDIEÆ.		
Batrachospermeæ	1	1
CHLOROPHYCEÆ.		
Coleochætaceæ	2	3
Œdogoniaceæ	2	16
Ulvaceæ	1	1
Ulotrichaceæ	3	3
Confervaceæ	2	3
Chroolepidaceæ	1	7
Cladophoraceæ	2	3
Pithophoraceæ	1	1
Zygnemaceæ	2	3
Desmidiaceæ	21	246
Palmellaceæ	14	26
MYXOPHYCEÆ.		
Rivulariaceæ	1	3
Sirosiphoniaceæ	3	5
Scytonemaceæ	2	5
Nostoceæ	2	2
Vaginarieæ	2	3
Lyngbyeæ	5	12
Chroococcaceæ	3	3
BACILLARIEÆ.		
Cymbelleæ	2	3
Naviculeæ	4	13
Gomphonemeæ	1	2
Achnantheæ	2	2
Epithemieæ	4	12
Synedreæ	1	4
Fragilarieæ	1	2
Tabellarieæ	1	1
Surirellieæ	1	2
Nitzschieæ	1	5
Melosireæ	1	2
Biddulphieæ	1	1
Total	90	395

EXPLANATION OF THE PLATES.

a, a′ = cellula vel semicellula a fronte visa.
b, b′ = „ „ „ a vertice visa.
c = „ „ „ a latere visa.
d = semicellula a basi visa.

PLATE 17.

Figs. 1, 2. *Œdogonium suboctangulare*, sp. n. × 220.
3–5. „ *spirale*, Hirn, var. *acutum*, var. n. × 520.
6, 7. „ *elegans*, sp. n. × 520.
8, 9. *Bulbochæte spirogranulata*, sp. n. × 520.
10. „ *minuta*, sp. n. × 520.
11. *Herposteiron crassisetum* sp. n. × 520.
12, 13. *Cladophora incurvata*, sp. n. 12, × 3; 13, × 60.
14, 15. *Desmatractum plicatum*, gen. et sp. n. 14, × 520; 15, × 830.
16, 17. *Scenedesmus quadricauda*, Bréb., var. *opoliensis*, nob. × 520.
18. *Rhaphidium polymorphum*, Fresen., var. *Turnerii*, nob. × 520.

PLATE 18.

Figs. 1, 2. *Cylindrocystis pyramidata*, sp. n. × 520.
3, 4. *Penium heterotaphridium*, sp. n. × 520. 4, zygospore.
5. „ *lanceolatum*, W. B. Turn., var. *subcylindricum*, var. n. × 520.
6. „ *spirostriolatiforme*, sp. n. × 520.
7. „ *minutum*, Cleve, var. *elongatum*, nob. × 520.
8, 9. „ *spinospermum*, Josh., forma minor. × 520. 9, zygospore.
10. „ *variolatum*, West & G. S. West, forma. × 520.
11. *Closterium subcompactum*, sp. n. × 520.
12. „ *pleurodermatum*, sp. n. × 520.
13. „ *striolatum*, Ehrenb., var. *robustum*, var. n. × 520.
14–16. „ *subporrectum*, sp. n. × 520.
17, 18. „ *exiguum*, sp. n. × 520.
19. „ *validum*, sp. n. × 520.
20. „ *Delpontii*, Wolle, var. *elongatum*, var. n. × 520.
21. „ *Kützingii*, Bréb., var. *vittatum*, Nordst. Forma duplo-minor. × 520.
22, 23. „ *gracile*, Bréb., var. *tenue*, nob. × 520.
24–26. „ *anastomosum*, sp. n. × 520.
27. *Pleurotænium Ehrenberghii*, De Bary, var. *Borgei*, var. n. × 520.
28. „ „ „ var. *undulatum*, Schaarschm. × 520.
29–32. „ *elatum*, Borge, var. *conjunctum*, nob. Forma duplo-major. 29, 30, × 220; 31, 32, × 520.
33, 34. „ *Kayei*, Rabenh. × 520.

PLATE 19.

Figs. 1, 2. *Pleurotænium perlongum*, sp. n. × 520.
3, 4. „ *hypocymatium*, West & G. S. West, var. *angustum*, var. n. × 520.
5, 6. „ *annulatum*, West & G. S. West. × 520. Fig. 5 is an accurate drawing of one of Joshua's original Burmese specimens. Fig. 6 is from a Ceylon specimen.
7, 8. „ *trochiscum*, West & G. S. West. × 520.
9, 10. „ *doliforme*, sp. n. × 520.
11. *Docidium manubrium*, West & G. S. West, var. *tenue*, var. n. × 520.
12. *Euastrum dideltoides*, sp. n. × 520.
13. „ *lobulatum*, Bréb., var. *tropicum*, var. n. × 520.
14, 15. „ *intermedium*, Cleve, var. *compactum*, var. n. × 520.
16. „ *sinuosum*, Lenorm., var. *ceylanicum*, var. n. × 520.
17. „ „ „ var. *Subjenneri*, var. n. × 520.
18, 19. „ *ligatum*, sp. n. × 520.
20. „ *spinulosum*, Delponte, var. *ceylanicum*, var. n. × 520.
21. „ „ „ subsp. *africanum*, Nordst. × 520.
22, 23. „ „ „ subsp. *inermis*, Nordst. × 520.
24. „ *longicolle*, Nordst., var. *capitatum*, var. n. × 520.
25. „ *Freemanii*, sp. n. × 520.

PLATE 20.

Fig. 1. *Euastrum egregium*, sp. n. × 520.
2, 3. „ *spicatum*, W. B. Turn., forma. × 520.
4. „ *bellum*, Nordst., var. *madagascariense*, West & G. S. West, forma. × 520.
5, 6. „ *plesiocoralloides*, sp. n. 5, × 830; 6, × 520.
7, 8. „ *geometricum*, sp. n. 7, × 830; 6, × 520.
9, 10. „ *truncatum*, Joshua. × 520.
11. „ *pulcherrimum*, sp. n. × 520.
12. „ *rostratum*, Ralfs, forma. × 520.
13. „ „ „ forma. × 520.
14, 15. „ *basichondrum*, sp. n. 14, × 830; 15, × 520.
16. „ *denticulatum*, F. Gay, forma. × 520.
17, 18. „ *fissum*, sp. n. 17, × 520; 18, × 830.
19. *Micrasterias urniformis*, sp. n. × 520.
20. „ *mahabuleshwarensis*, Hobson, var. *surculifera*, Lagerh. × 520.
21. *Xanthidium quadridentatum*, sp. n. × 520.
22, 23. „ *lepidum*, sp. n. × 520.
24, 25. „ *ceylanicum*, sp. n. × 520.
26. „ *inconspicuum*, sp. n. × 1280.
27. „ *brevicorne*, W. B. Turn., var. *ceylanicum*, var. n. × 520.
28. „ *Freemanii*, sp. n. × 520.
29. *Cosmarium tithophorum*, Nordst., var. *depressum*, var. n. × 520.
30. „ *bireme*, Nordst. × 520.
31. „ *bipaxillum*, sp. n. × 830.
32, 33. „ *Subreinschii*, Schmidle, var. *ocellatum*, var. n. × 520.

Fig. 34. *Cosmarium Pseudoscenedesmus,* sp. n. × 520.

35. „ *Regnesii,* Reinsch, var. *productum,* var. n. × 520.

36–38. „ *sulcatum,* Nordst., var. *incrassatum,* var. n. × 520. 38, zygospore.

39, 40. „ *trachypolum,* West & G. S. West, var. *elongatum,* var. n. × 520.

41. „ *dorsogranulatum,* sp. n. × 520.

42. „ *globosum,* Buln., var. *Wollei,* West & G. S. West, forma. × 520.

43–45. „ *pseudoconnatum,* Nordst., var. *ellipsoideum,* var. n. × 520.

PLATE 21.

Fig. 1. *Cosmarium medioscrobiculatum,* sp. n. × 520.

2. „ *Pardalis,* Cohn. × 520.

3. „ *decoratum,* West & G. S. West, var. *dentiferum,* var. n. × 520.

4. „ *Pseudobroomei,* Wolle. × 520. Two forms.

5. „ *biscrobiculatum,* sp. n. × 520.

6, 7. „ *pterophorum,* sp. n. 6, × 830; 7, × 520. The elongate projection from each side of the *vertical view* (7 *b*) has been accidentally omitted from the drawing. The lettering of the front and lateral views should also be interchanged.

8–10. „ *Freemanii,* sp. n. × 520.

11. „ *cuneatum,* Joshua. × 520.

12, 13. „ *spinuliferum,* sp. n. × 520.

14, 15. „ *ceylanicum,* sp. n. × 520.

16, 17. *Staurastrum unicorne,* W. B. Turn., var. *ceylanicum,* var. n. × 520. 17, abnormal result of division.

18. „ *alternans,* Bréb., var. *divergens,* var. n. × 520.

19. „ *villosum,* sp. n. × 520.

20. „ *giganteum,* sp. n. × 520.

21. „ *Freemanii,* sp. n. × 520.

22. „ „ var. *triquetrum.* × 520.

23. „ *heneratgodhense,* sp. n. × 520.

24. „ *quadricornutum,* Roy & Biss., var. *patens,* var. n. × 520.

25. „ *gemelliparum,* Nordst. × 520.

26. „ *tohopekaligense,* Wolle. × 400. From an original specimen received from the late Rev. Francis Wolle.

27. „ *tohopekaligense,* Wolle, var. *trifurcatum,* West & G. S. West. × 520. One semicell possesses 3 processes in the inferior whorl and the other 9 processes in the inferior whorl.

28. „ *tohopekaligense,* Wolle, var. *insigne,* var. n. × 520.

29, 30. „ *leptacanthum,* Nordst. × 520. Two sizes of individuals.

31, 32. „ *zonatum,* Börges., var. *ceylanicum,* var. n. × 520.

33. „ *pinnatum,* W. B. Turn., var. *subpinnatum,* nob. × 520.

34. „ *sexangulare,* Rabenh., forma. × 520.

35. „ „ var. *subglabrum,* var. n. × 520.

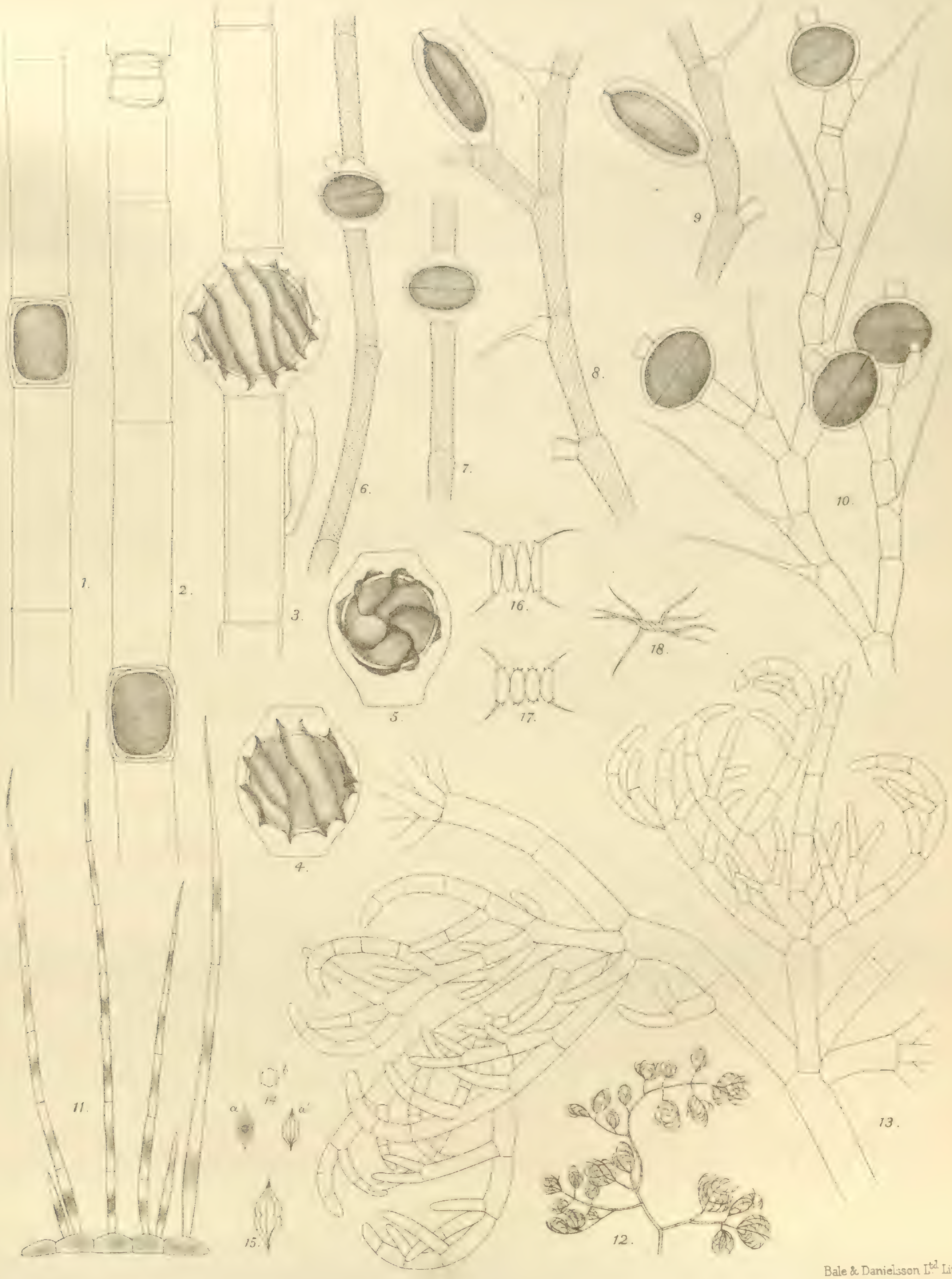
36. „ *biordinatum,* sp. n. × 520.

PLATE 22.

Fig. 1. *Staurastrum acanthastrum,* sp. n. × 520.

2. „ *ceylanicum,* sp. n. × 520.

Fig. 3. *Staurastrum acestrophorum*, sp. n. × 520.
4. „ *Cerastes*, Lund., var. *ceylanicum*, var. n. × 520.
5. „ *approximatum*, sp. n. × 520.
6. „ *triforcipatum*, sp. n. × 520.
7. „ *subparvulum*, sp. n. × 520.
8, 9. „ *columbetoides*, sp. n. × 520.
10–12. „ *indentatum*, sp. n. × 520.
13, 14. „ *saltans*, Joshua. × 520.
15. „ *subsaltans*, sp. n. × 520.
16. „ *Submanfeldtii*, sp. n. × 520.
17. „ „ var. *elegans*. × 520.
18. „ *cyclacanthum*, sp. n. × 520.
19. „ *galeatum*, W. B. Turn. × 520.
20. „ *gracile*, Ralfs, var. *elegantulum*, var. n. × 520.
21. *Arthrodesmus phimus*, W. B. Turn. × 520.
22. „ *gibberulus*, Joshua. × 520.
23–25. *Staurastrum tauphorum*, sp. n. × 520.
26. *Hyalotheca mucosa*, Ehrenb., var. *minor*, Roy & Biss. × 520.
27. „ *undulata*, Nordst., forma. × 520.
28. *Sphærozosma granulatum*, Roy & Biss., var. *pergranulatum*, var. n. × 520.
29, 30. *Spondylosium compactum*, sp. n. 29, × 830; 30, × 520.
31. *Onychonema uncinatum*, G. C. Wall., var. *subglabrum*, var. n. × 520.
32–34. *Phymatodocis irregulare*, Schmidle. × 520.
35–37. *Desmidium Pseudostreptonema*, sp. n. × 520. Figs. 36 and 37 are the triangular form, and Fig. 35 is a 2-ended form.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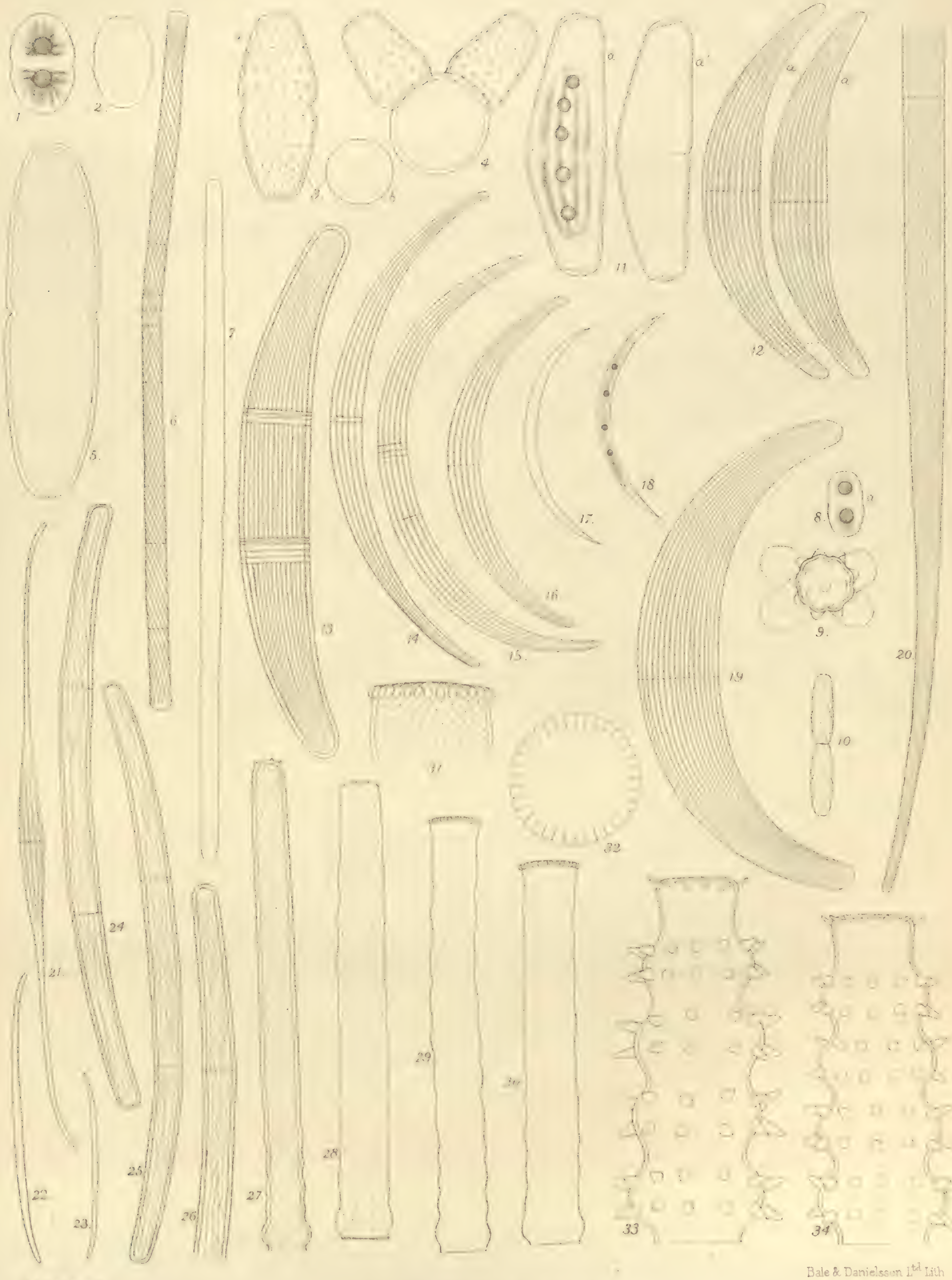
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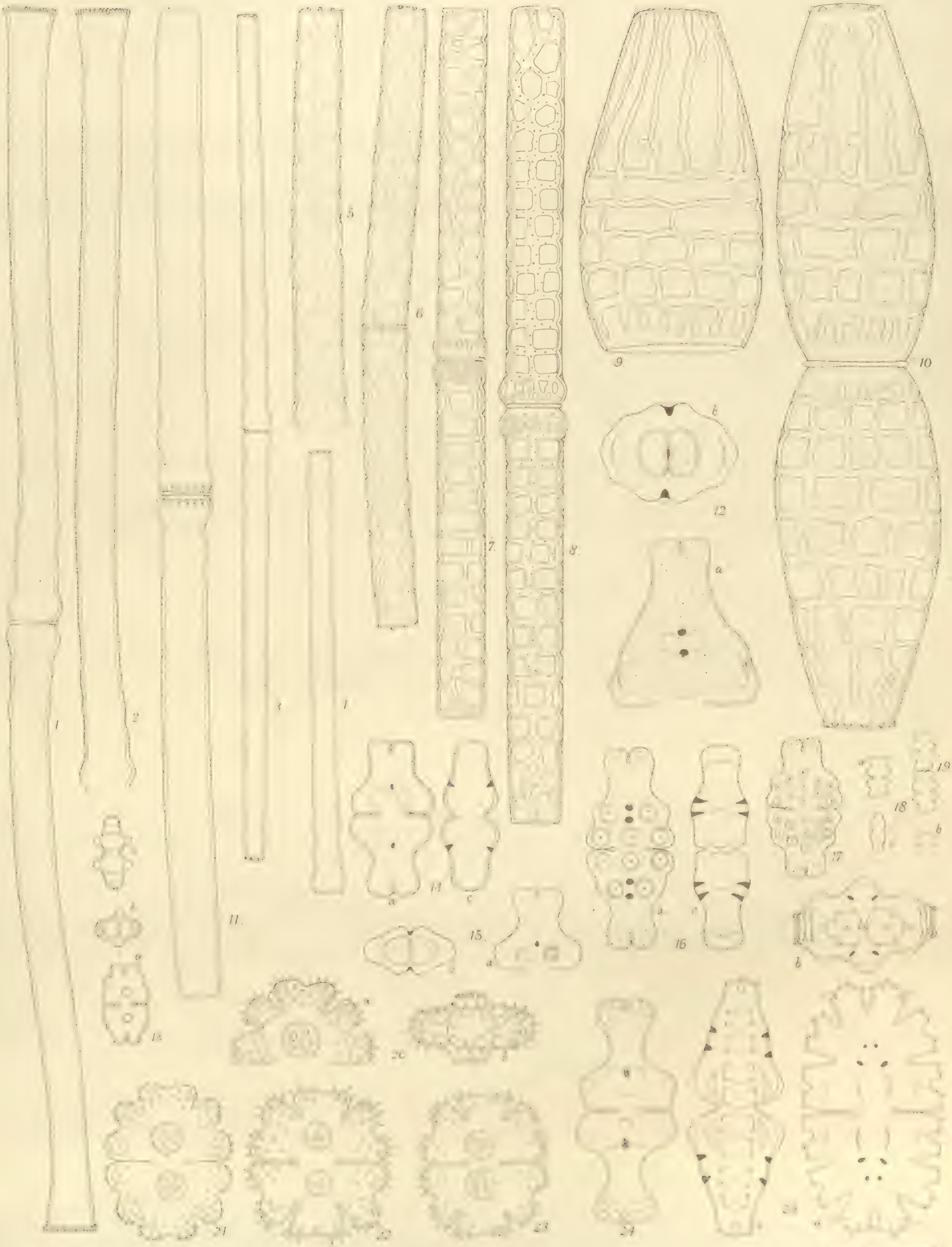
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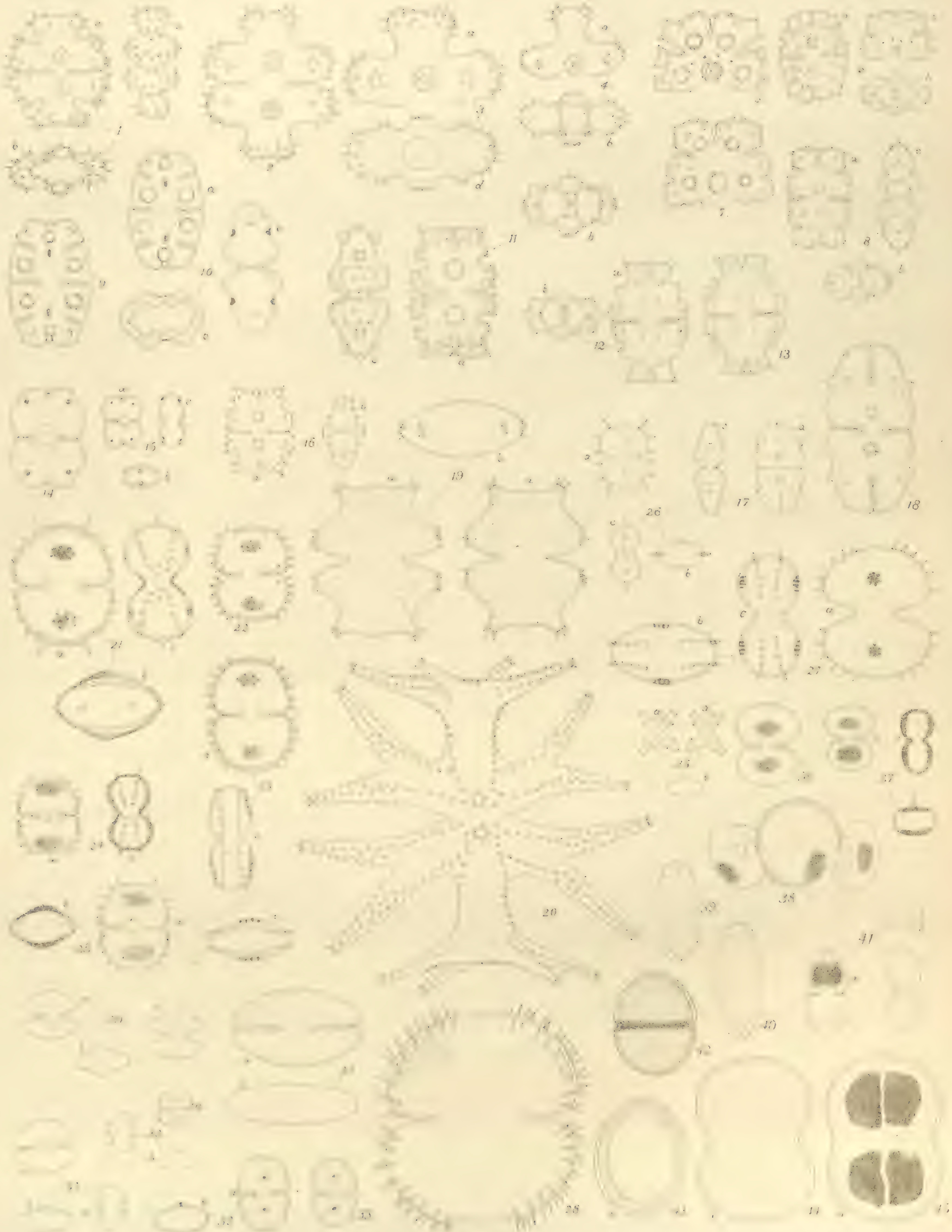
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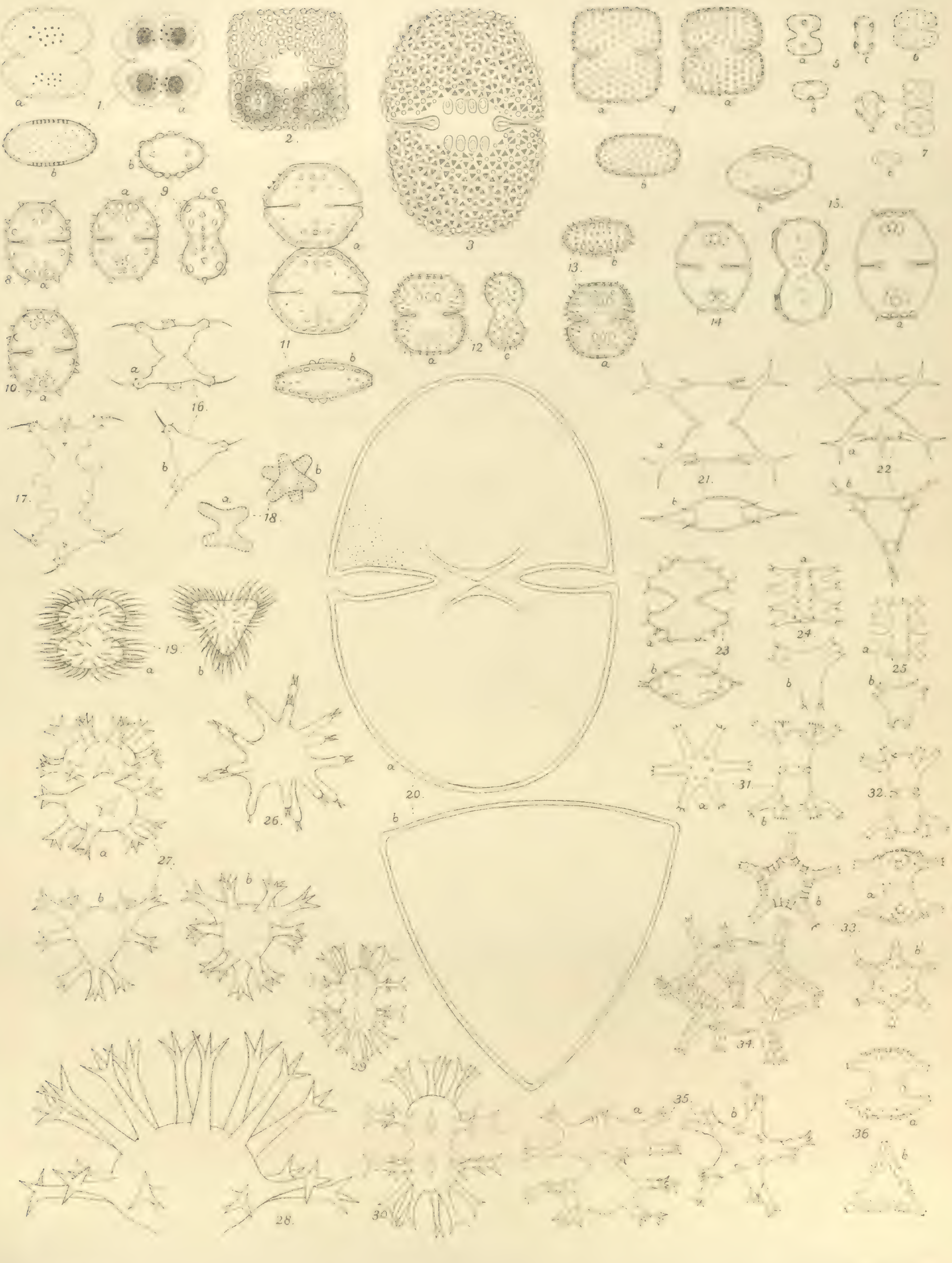
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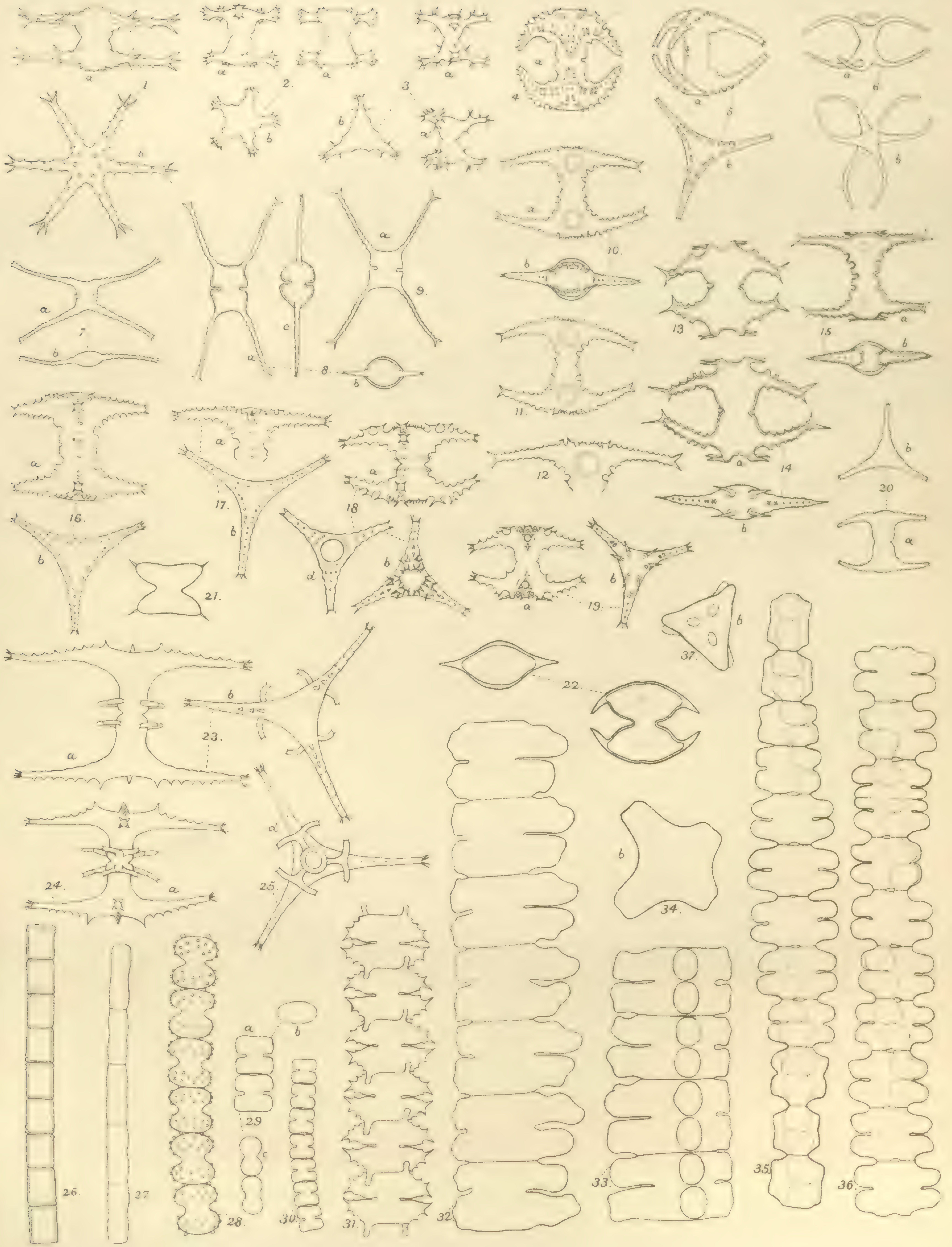
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Bale & Danielsson L^{td} Lith

DESMIDS FROM CEYLON.

LINNEAN SOCIETY OF LONDON.

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	Part XIV. 1900.	0	3	0	0	2	3
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2nd Ser. BOTANY.] [VOL. VI. PART 4.

THE TRANSACTIONS OF THE LINNEAN SOCIETY OF LONDON.

A BISERIATE HALONIAL BRANCH OF LEPIDOPHLOIOS FULIGINOSUS.

BY

F. E. WEISS, D.Sc., F.L.S.,

PROFESSOR OF BOTANY IN THE OWENS COLLEGE, MANCHESTER.

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January 1903.

IV. *A Biseriate Halonial Branch of* Lepidophloios fuliginosus. *By* F. E. Weiss, *D.Sc., F.L.S., Professor of Botany in the Owens College, Manchester.*

(Plates **23–26.**)

Read 3rd April, 1902.

In the autumn of 1898 I purchased from Mr. James Lomax an *Halonia,* together with an excellent series of transverse and longitudinal sections prepared by him from the same specimen and which showed the tissues to be very well preserved. From an examination of the latter Mr. Lomax had rightly identified the plant with that described by Williamson originally (1873) as *Lepidodendron Harcourtii,* but afterwards renamed *Lepidodendron fuliginosum* (1887).

I was unaware at the time that Dr. Scott had exhibited a photograph of the specimen at the Bristol Meeting of the British Association in that year and had commented on certain peculiarities of its structure. On expressing my willingness to leave the further examination and fuller description of this specimen to him, Dr. Scott most generously withdrew his prior claims upon it and also allowed me to make use of some preparations he possessed of this plant, from one of which one of the accompanying figures is taken. I desire here to express my indebtedness to him, both for his generosity and also for his helpful criticism of several points in connection with the structure of this halonial branch.

I. Morphological Considerations.

The *Halonia* under consideration was contained in a large nodule weighing nearly 2 cwt., found by Mr. George Wilde at Hough Hill, near Stalybridge. Mr. James Lomax was able to extract from this nodule a large piece of the halonial branch measuring about 7 inches in height and $3\frac{1}{2}$ to $3\frac{3}{4}$ inches in its greatest diameter by about $2\frac{1}{2}$ inches in the shorter diameter (Pl. **23.** fig. 1). There were eight tubercles arranged in two rows of four each, alternating with each other at the two sides which form the ends of the greater diameter of the stem. The internal structure shows so little sign of compression, that I think in all probability this difference in thickness in the two directions actually existed in the living plant, though it may have become slightly increased by pressure during mineralization.

There are no leaf-bases present, part of the specimen being clothed by the periderm formed beneath the leaf-bases and showing a slight indication of "dictyoxylon" markings. At other points of the surface the periderm has been removed, and the outer cortex forms the boundary, with small elevations of tissue in connection with the leaf-trace bundles. The relative position of these is such that on connecting the two nearest lateral ones the distance between them is almost equal to that between two standing vertically one above the other.

The internal structure will be described in detail in a later portion of this paper; so that it will be sufficient to say here that it agrees very closely with that described by Williamson for *Lepidodendron fuliginosum* (*Lepidophloios fuliginosus*)—a fact already stated by Dr. Scott (1898) and Mr. Lomax (1899).

In his communication to Section K at the Bristol Meeting of the British Association, Dr. Scott mentioned this agreement in structure, and regarded this halonial specimen as probably belonging to *Lepidodendron fuliginosum*.

At the meeting of the British Association at Leeds, however, in 1890, Messrs. W. Cash and James Lomax (1890) had shown that a fossil revealing undoubtedly similar internal structure to that of *Lepidodendron fuliginosum* of Williamson had the typical transversely elongated leaf-scars of *Lepidophloios*. Hence they suggested the name of *Lepidophloios fuliginosus* for the stem previously described by Williamson. Williamson, however, in Part XIX. of his Memoirs on the Organization of the Fossil Plants of the Coal-Measures, which appeared three years later, 1893, still retained the name of *Lepidodendron fuliginosum* for the fossil described by himself, and probably did not sufficiently appreciate the separation of the two genera, for in a note to a "Correction of an Error of Observation in Part XIX. &c." in 1894, he states: "It appears to me that much uncertainty exists among palæobotanists respecting the structures that distinguish *Lepidodendron* from *Lepidophloios*" *.

It is probably due to the retention of the name *Lepidodendron fuliginosum* by Williamson after the publication of Messrs. Cash and Lomax's note, that their observation did not receive its full recognition for some time and that the name *Lepidodendron fuliginosum* was retained for so long.

Mr. Kidston (1893), however, in his memoir on *Lepidophloios* and on the British species of the genus, had duly recorded the observation of Messrs. Cash and Lomax, and after an examination of their specimen was inclined to identify it with *Lepidophloios acerosus*.

An examination of the transverse sections of the specimen described by Cash and Lomax (1890) in the Cash Collection, now in the Manchester Museum, has convinced me of the identity in structure of this *Lepidophloios* with that of Williamson's *Lepidodendron fuliginosum*, and also with the internal structure of the halonial branch forming the subject-matter of the present investigation.

Having identified the halonial branch now under consideration with *Lepidophloios fuliginosus* on the strength of its internal structure, the next and probably the greatest point of interest attaches to the fact that, if the identification is correct, we have in this instance an halonial branch of *Lepidophloios* with two vertical rows of tubercles, instead of the spiral arrangement of tubercles usually considered typical of the fruiting-branches of *Lepidophloios*. Indeed, according to some definitions of *Halonia*, our specimen would not be an halonial but a ulodendroid branch, and therefore not referable to the genus *Lepidophloios*.

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* Proceedings of the Royal Society, vol. lv. (1894) p. 423, note.

Thus Kidston (1893), in his memoir on *Lepidophloios*, states: "If it is necessary to define a difference between the *Ulodendron*-condition and the halonial condition even in the absence of the bark they can be separated, the former having two rows of alternate (usually) cup-shaped scars, the latter having more than two rows of (usually) conical tubercles spirally arranged."

On the other hand, Williamson in the same year (1893), after discussing at some length the various specimens of *Halonia* and *Ulodendron* known to him, comes to the conclusion "that the only distinction between halonial and ulodendroid conditions lies, not in the number or arrangement of the fruit-scars, but in the presence or absence of a pressure-disk surrounding each fruit-scar."

It will be seen from these two definitions that the halonial condition is according to Williamson a very different thing from the halonial condition defined by Kidston, the latter basing his definition on the number of rows of scars or tubercles, while Williamson disregards their number but distinguishes the elevated tubercles of *Halonia* from the cup-shaped pressure-disks of *Ulodendron*.

In calling the specimen under consideration an halonial rather than a ulodendroid branch, it will be seen that I incline to Williamson's view that the elevation of the tubercles is a more distinctive feature than their number or arrangement.

I cannot believe that absence or presence of an elevation is due merely to presence or absence of pressure during mineralization or to absence or presence of a well-preserved covering of leaf-bases. A number of fruiting-branches of *Lepidophloios* are known with the leaf-bases well preserved still showing fairly prominent tubercles, though of course in "decorticated" specimens the tubercles are more prominent *. Similarly, in an *Halonia* which has evidently been much compressed the tubercles are clearly distinguished, even on the surfaces which have been most exposed to pressure. Pl. 23. figs. 2 & 3 of the present memoir show the two sides of the same halonial branch, which exhibits distinct tubercles on one side (fig. 2), while on the other (fig. 3) the branches have the character of flattened or cup-shaped areolæ. This difference depends on differences of position or condition during mineralization.

I would therefore describe the "halonial condition" as the fruiting-branch of *Lepidophloios* bearing a number of more or less elevated tubercles either in quincuncial or in biserial arrangement.

This description of the halonial branch would agree in general with that given by Williamson (1893), and would also agree in this particular with the views expressed by Kidston (1886 and 1893) and by Potonié (1893 and 1899), that, so far as is at present known, the halonial condition is restricted to the genus *Lepidophloios*. On the other hand, the view I have adopted differs from that held by Kidston and Potonié in not restricting the term "halonial" to branches with the quincuncial arrangement of tubercles. That *Lepidophloios* is, however, not restricted to multiseriate fruiting-branches is borne out from an examination of the halonial branch under consideration, which, on the strength of its internal structure, must be identified with *Lepidophloios fuliginosus*. As, however, an identification based solely on the internal structure might be disputed by some, I would seek to strengthen my conclusion by evidence from specimens showing external markings which can be identified with *Lepidophloios* and which at the same time possess only two rows of tubercles.

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* The term "decorticated," so much in use in the description of halonial branches, is misleading, for it has not been employed to describe stems in which the cortex is absent but in which the leaf-bases or cushions are worn away and in which consequently the leaf-scars are not distinguishable. Thus the specimen under examination would be termed "decorticated," whereas even the outer cortex is completely preserved.

There is in the Manchester Museum a specimen, reproduced in figs. 2 and 3, which was found in the roof of the Four Foot Mine at Tonge, near Bolton. It was presented to the Museum by Mr. Dawes. It is a branch about 14 inches in length, and shows the commencement of a bifurcation at one end, an occurrence not infrequently met with in halonial branches. It is considerably compressed, so that its diameter in one direction is $3\frac{3}{4}$ inches, while in the other it measures only $1\frac{1}{2}$ inch. It possesses two rows of tubercles, two tubercles being visible on each side of the specimen about 4 to 5 inches apart. The pressure has been exerted on the sides bearing the two rows of tubercles; yet these are still distinctly recognizable as elevations, especially on the side shown in fig. 2. That this would be the case even if the leaf-cushions were present is evident from the thinness of the leaf-cushions where preserved. This outer layer of the leaf-cushions is the only carbonized portion of the plant, the central portion of the branch being entirely replaced by limestone. The width of the leaf-cushions and their imbrication, overlapping from above downwards (see Pl. 23. fig. 4), leave no doubt in my mind that this is a specimen of *Lepidophloios*, though it is true that no actual leaf-scar is distinguishable, as the specimen is not in the best state of preservation. But it agrees very closely with an halonial specimen described by Carruthers (1870) as *Ulodendron tumidum*, which has since been identified by Kidston (1886) as *Lepidophloios laricinus* (Sternberg). In this latter specimen some actual leaf-scars are preserved, but in parts these are not distinguishable, and there we have the closest agreement in its arrangement with the leaf-bases of the biserial *Halonia* of the Manchester Museum. In both cases the remains of the leaf-bases are drawn out in breadth and are ragged and torn.

I think, therefore, we are justified in assuming that this biseriate halonial branch is also referable to the genus *Lepidophloios*. In Mr. Carruthers's specimen the tubercles are rather irregularly arranged. From the name *Ulodendron* which he gave to this specimen, it is obvious that the biseriate arrangement is that which strikes the observer at first; but Kidston has shown that we have really more than two rows in this specimen.

Another specimen of *Lepidophloios* bearing two rows of tubercles I discovered in the Williamson Collection at the British Museum (Pl. 24. fig. 5). This halonial branch (cabinet-number 1946 B) is not described in Williamson's detailed and useful catalogue, but is merely entered as *Lepidophloios*. It is a small piece of a fruiting-branch, 3 to 4 inches long and 3 inches by 2 in thickness, thus showing very little compression. The leaf-bases are perfectly distinct over the whole surface, and their broad and fimbriating nature mark them out as belonging to *Lepidophloios*, as indeed was recognized by Williamson. Their state of preservation is unfortunately not perfect, the actual leaf-scar not being distinguishable. In this specimen the tubercles are arranged in two distinct rows at the end of the greater diameter of the branch, and two tubercles are borne on each side. We have therefore here another case of an halonial branch of *Lepidophloios* with two rows of tubercles.

Unfortunately in this case, too, the interior of the branch is not well preserved, but has become impregnated with pyrites, so that we cannot say whether the tissues of this specimen agreed with those of *Lepidophloios fuliginosus* or not.

Evidence of *Lepidophloios* possessing fruiting-branches with only two rows of tubercles, based upon specimens not showing the external marking of the leaf-bases, but exhibiting well-preserved internal structure, will be found in Williamson's 'Memoirs.'

Thus in Part II. (p. 209) he describes a small specimen of *Ulodendron* received from Mr. Neild of Oldham, and states that the structure of its central axis is identical with that of the *Lepidodendron* of the *fuliginosum* type (then called by him *Harcourtii*). Although the figures of this specimen are not very good, the identification of its structure with that of *Lepidodendron fuliginosum* is correct, and we have therefore a specimen with the internal structure of *Lepidodendron fuliginosum* (now *Lepidophloios*) and bearing the two rows of "circular areolæ of *Ulodendron*." That the specimen is a *Lepidophloios* is ascertainable not only from the central axis of the *fuliginosum* type, but also from the leaf-bases seen in transverse section in fig. 28 of Williamson's memoir, and in longitudinal section fig. 27. Solms (1892), who is rightly rather sceptical about this specimen being referred to *Ulodendron* and considers that it is probably *Lepidophloios*, regrets that Williamson did not figure the surface-view so as to show the "circular areolæ of *Ulodendron* arranged in two vertical rows" (p. 232). Though this was no doubt a pity, yet in the light of the specimens referred to above, and on the strength of others to be mentioned below, we cannot now doubt that two such rows of scars were present, and the importance of this specimen becomes apparent.

In Part XIX. Williamson (1893) figures another halonial branch with its tubercles in two rows (fig. 22); but as this specimen shows no external markings of leaf-bases, and as Williamson does not figure its internal structure, it yields no evidence in support of the views I seek to maintain.

In the same memoir (Part XIX.) is described and figured (fig. 30) a transverse section of a branch of *Lepidophloios* which bears large "bilateral fructigerous tubercles." This specimen was collected by Mr. George Wilde from the Hough Hill Colliery of Stalybridge, the same locality from which the specimen now under consideration was obtained. In his description of this earlier specimen, Williamson says (p. 20): "The specimen was one in which the large halonial protuberances had been in two lateral series, three of these protuberances being preserved. Its leaves show that it belonged to the lepidophloioid group, and present every appearance of identity with the plant which is described and figured in my Memoir, Part II. (figs. 24–28)."

This statement is fully borne out by Williamson's figures as well as by an examination of some transverse and longitudinal sections of this specimen in the Wilde Collection in the Manchester Museum. What remains of the original specimen after the sections were cut from it was carefully preserved by Williamson and is described in his Catalogue, under No. 1949 A, as "part of the original specimen preserved to show one of the large halonial tubercles." This piece, so judiciously preserved by Williamson, shows this remaining tubercle very clearly. Another piece of this branch was preserved by Mr. Wilde, and is now in the Wilde Collection at the Manchester Museum. This piece, from which the central portion of the axis has disappeared, consists of the outer portion of the nodule with the leaf-bases and part of the cortex preserved. It shows three large scars in vertical series, which were no doubt three of the "ulodendroid" scars.

The importance of this specimen lies in the preservation of the leaves, from which there is no doubt that the plant was referable to the genus *Lepidophloios*; and hence we have in this case, too, a fruiting-branch of *Lepidophloios fuliginosus* in which the cones were attached in two vertical rows. We see therefore that Williamson has in this case described a *Lepidophloios* with biseriate halonial tubercles.

In the case of the specimen (cabinet-number 379) figured by Williamson (1881) in his XIth Memoir (fig. 9), and for which he at first retained the name of *Lepidodendron Harcourtii* (see Proc. Royal Soc. vol. xlii. 1887), but which he subsequently transferred to *L. fuliginosum* (see his General and Morph. Index, Part II. p. 13, 1893), we have undoubtedly an halonial stem giving off a branch from the central vascular cylinder to an halonial tubercle, as Williamson himself thought was the case (p. 290). The elliptical shape of the stele and its general similarity in the mode of branching with that in Lomax's specimen would seem to point out that here also we have two rows of tubercles. If this should be the case, we shall have another instance of a biseriate halonial branch belonging to the genus *Lepidophloios*.

The consideration of the above-mentioned specimens of biseriate halonial branches shows that such branches may be referred to the genus *Lepidophloios* in some cases by their external markings, in other cases on the strength of their internal structure. These instances therefore support the view put forward with regard to the Hough Hill halonial branch now under consideration, that it is the fruiting-branch of *Lepidophloios fuliginosus*. This view is of course opposed to Kidston's definition of *Halonia*; for he considers halonial branches to be characterized by multiseriate tubercles, and these only to be referable to the genus *Lepidophloios*, and he does not recognize the "biserial Halonias" of D'Arcy Thompson (1880). The biseriate arrangement Kidston considers to be the ulodendroid fruiting-branch of *Bothrodendron*, *Sigillaria*, or *Lepidodendron*. He would therefore refer the specimen forming the subject of this paper, as he has done the *Halonia disticha* described and figured by Morris (1840) in Prestwich's account of the geology of Coalbrookdale, to *Sigillaria discophora*. In Morris's *Halonia*, however, neither the leaf-bases nor the internal structure is preserved, whereas in the present specimen the internal structure is undeniably that of *Lepidophloios*, as will be readily seen from the detailed account of its anatomical structure which follows.

II. ANATOMICAL STRUCTURE.

The identification by Dr. Scott (1898) of the halonial branch under consideration as belonging to *Lepidophloios fuliginosus* will be confirmed by the details of the structure which will now be given.

The general view of the transverse section (Pl. 24. fig. 6) will be seen to resemble in its chief features the *Lepidodendron fuliginosum* (previously called *Harcourtii*), figured by Williamson (1881) in Part XI. of his "Organization of the Fossil Plants of the Coal-Measures" (see pl. 52. fig. 9). Our specimen differs from Williamson's in the better preservation of the mid-cortex, which is practically perfect. This difference in preservation is doubtlessly due to a difference in the minute structure of this tissue. Though with small magnification there appears to be a considerable "uniformity in the composition of the entire cortex," as Williamson states (p. 7), yet there is, as we shall see on closer examination, a very considerable difference between the inner, the middle, and the outer cortex.

Another feature which distinguishes at a glance the specimen under consideration from *Lepidodendron Harcourtii* is the course of the leaf-trace bundles through the mid-cortex. It will be seen that these run very obliquely through this tissue, at times indeed nearly horizontally, as is especially the case in the bundles running in the direction of the longer diameter of the elliptical section. This character is more frequently found in *Lepidophloios fuliginosus* than in other *Lepidodendra*, and is certainly characteristic of that specimen to which Williamson first gave the specific name of *fuliginosus*; for it is to the specimen figured in plate 51 (fig. 10) of Part XI. that he referred in his note of 1887, when he introduced this new specific name, and in that specimen the leaf-trace bundles run very nearly horizontally through the middle cortex.

Other specimens of *Lepidophloios fuliginosus* in the collections of the Manchester Museum also show this very horizontal course of the vascular bundles; and I would like more particularly to mention one in the Wilde Collection (No. 158) which is labelled an halonial stem, and which, from its more circular outline and smaller dimensions, I think must have belonged to a multiseriate *Halonia*. That it is an halonial stem is indicated by the branch which is given off from the central vascular cylinder. The uniformity, both in respect to the course of the leaf-trace bundles and to the detailed structure of the cortex and other tissues, convinces me that no distinction can be made anatomically between this specimen and that under consideration.

Another feature which is characteristic of *Lepidophloios fuliginosus* is the peculiar formation of the secondary tissues formed around the primary xylem cylinder. This, as is seen in Pl. 24. fig. 7, Pl. 25. fig. 11, and Pl. 24. fig. 12, is of almost precisely the same nature as that figured by Williamson (Part XI. pl. 49. fig. 11) as the "rudimentary exogenous zone."

After these general observations, we will pass to a detailed consideration of the tissues.

The Stele.

The centre of the stele is occupied, as is seen from Pl. 24. figs. 6 & 7, by medullary tissues, the cells of which are for the most part considerably compressed. Only the three or four outermost rows of cells show a definite lumen, and from these the nature of the pith-cells can be established. In transverse section they are more or less polygonal in shape. In longitudinal section it will be seen (Pl. 25. fig. 10) that the primary cells have grown considerably in length and fit very closely together with pointed ends. These cells have divided up repeatedly by transverse and oblique walls. Sometimes two rows of these small polygonal cells are found within the elongated primary cells. A pith of this kind has been described and figured by Williamson (1873) (Pl. 24. fig. 14) for *Lepidophloios fuliginosus*, and occurs in other lepidodendroid stems. It is not an unusual condition for the medulla and cortex of recent plants. The cells seem all to be of a parenchymatous character; and I was not able to detect any elements with reticulated walls such as occur in *Lepidodendron vasculare* (Binney) *, and as have been described by Seward (1899) in a stem of *Lepidophloios fuliginosus.*

The primary wood which encloses the pith consists of eight or ten layers of tracheids decreasing in diameter towards the periphery, where the wood ends in sharp cusps composed of the smallest elements (protoxylem). From these the vascular supply of the leaf-trace bundles is given off, and in the depression between two consecutive cusps there will be seen to the outside of the primary xylem the vascular elements which have been given off at a lower level.

The inner portion of the primary wood is seen to consist of large tracheids with scalariform marking. The smaller elements near the periphery seem to be narrow tracheids. In transverse section the tracheids are more or less polygonal in outline, and often show a splitting apart of the wall between two contiguous cells. Most of the cells are devoid of contents, but in some cases the cell-space is filled with a dark brown mass.

The groups of elements which are given off to form the leaf-traces consist of both smaller and larger cells, the former generally enclosed by the latter, thus forming a mesarch group (Pl. 25. fig. 13). This mesarch arrangement is not always visible immediately on leaving the primary xylem. At first the course of the leaf-traces is nearly vertical, and it is not until they enter the mid-cortex that they become oblique or nearly horizontal.

The tissue immediately outside the primary wood consists of very small isodiametrical cells with dense contents, thus rendering them opaque and preventing their structure from being clearly seen. In this tissue lie the leaf-trace bundles just after they are given off from the primary wood. At a little distance from the primary wood the cells of the surrounding layer become larger and clearer and are more regularly arranged. Their contents are less dense than those of the cells nearer the wood, and they are consequently of a lighter colour. These are the layers that are considered from their regular arrangement to be of secondary origin.

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* *Lepidodendron selaginoides* (Will.).

The transverse section shows that this secondary growth does not take place uniformly round the axis, but, as is very generally the case in the *Lepidodendraceæ*, it is more extensive on one side of the stem. In Pl. **24.** figs. 6 & 7 it will be found largely, if not exclusively, on the lower side of the stele.

The specimen under consideration, though more than twice the size of that described by Williamson, has only a very little more secondary growth, confirming the belief that in this species the development of secondary wood did not take place to so great an extent as in other *Lepidodendraceæ*. At some parts of the circumference, indeed, there seems to be no secondary growth at all, and then there is a gradually increasing amount as one passes round the stem, decreasing again as one nears the starting-point. This condition allows us to see not only the actual secondary growth, but to follow out more or less the consecutive stages of its development.

Even where there is no actual secondary tissue formed, one notices, on the outside of the dense parenchymatous tissue in which the leaf-traces are at first embedded, a ring of more lightly coloured and thin-walled cells somewhat radially elongated. Within these, a little further on, will be found one or two rows of smaller squarish cells, and further on still they will be found to be more numerous and more regularly arranged. Seen in a transverse section, they are for the most part square in shape except the outermost layer just within the phloem, which, as stated above, is often considerably elongated in a radial direction (see Pl. **25.** fig. 13) and very light in colour. This ring of radially elongated cells is probably not of a meristematic nature, as it occurs, as will be seen later on, in the lateral organs in which no secondary thickening takes place. Probably one or more of the rows of cells within the radially elongated cells were of a meristematic nature, differing somewhat from the flattened cambium-cells of recent plants.

In those parts of the circumference where a considerable amount of secondary tissue has been formed, it will be noticed that certain rows of the secondary cells become more enlarged and appear to have somewhat thicker walls. These cells are generally empty, and are in transverse section not unlike the secondary tracheids of other *Lepidodendraceæ*. They are somewhat irregularly arranged, as in the secondary wood of *Lepidodendron Wünschianum*, and form slightly spindle-shaped groups of cells.

A similar condition for the same species is figured by Williamson (1881), pl. 49. fig. 11, and in his description of this section (p. 290) he calls the larger empty elements " barred vessels." An examination of a longitudinal section of our specimen (Pl. **25.** fig. 11), however, shows that these larger cells are short and square, and do not possess any scalariform marking.

It is of course possible that we have in this specimen a fairly young condition of the stem before the lignification of the secondary tissue. If this is the case, then it is conceivable that tracheids may yet be formed from the secondary tissue. But neither the transverse nor longitudinal sections are suggestive of the formation of tracheids, the whole of the secondary tissue having the appearance of parenchyma.

The very late development of secondary tracheids seems to be a characteristic feature of *Lepidophloios fuliginosus*, as far as can be gathered from the published accounts of this species and as I have also observed in the various specimens in the collections of the Manchester Museum.

In some specimens of *Lepidophloios fuliginosus* in the Cash Collection, though only about half the diameter of the specimen now before us, lignified elements are more strongly pronounced and show, where they are obliquely cut, scalariform marking. But the proportion of such thickened tracheids is very small in comparison with the parenchymatous cells of the secondary zone.

Outside the secondary tissues we come to the phloem region. As in other specimens of *Lepidophloios fuliginosus*, the phloem area is occupied in this specimen by large cells or spaces embedded in a small-celled tissue, which is, however, but indifferently preserved, so that the individual cells are not always recognizable (Pl. 24. figs. 7 & 12). These large round spaces are characteristic of most stems of *Lepidophloios*, and have been described by Bertrand (1891) in *Lepidophloios Harcourtii* as phloem elements. Seward (1899), however, after very careful examination, has come to the conclusion that this tissue is not a true phloem, but a secretory tissue, the large spaces being probably formed for the most part "during the life of the plant by the separation and partial disorganization of thin-walled cells."

I have given my reasons in a previous paper (Weiss, 1901) for dissenting from Seward's views, and for believing that this tissue is true phloem comparable with that of existing *Lycopodiaceæ*.

This conclusion is based upon the examination of some very perfectly preserved specimens of *Lepidophloios* from the Cash Collection in the Manchester Museum, in which the large sacs or spaces mentioned above are not present and in which the phloem shows a distinct resemblance to that of existing *Lycopodia*. The spaces appearing in the phloem of the present specimen and in most other specimens of *Lepidophloios* I consider due to partial disorganization, previous to mineralization it is true, but not during the life of the plant. That this disorganization is not generally apparent in other tissues I think must probably be connected with the fact that the cell-walls of the phloem in *Lycopodiaceæ* are often composed of amyloid, a carbohydrate less resistant than cellulose, of which the cell-walls of the other tissues are composed.

In his criticism of my views Seward (1902), while maintaining his interpretation of the tissue under question as of a secretory nature, agrees with me "as regards the probable phloem-function of this tissue." As its position and its connection with the leaf-traces render this function most probable, I should prefer to retain for it the name of phloem, even were it not identical in structure with that of recent Lycopodiales. But even in the living representatives of this group we have a very considerable range in the structure of the phloem if we include *Isoëtes*, for which Scott and Hill (1900) have definitely established the phloem nature of the secondary tissue of tabular cells. The difference between Seward and myself is, I think, largely one of terminology—Seward identifying the word phloem with a tissue possessing a definite anatomical character, whilst I use the term to describe a tissue having a certain physiological function.

The examination of the phloem in our specimen, where it has undergone some degeneration, would not be of much value. In one portion of the section the large spaces are absent, and one can see, though somewhat indistinctly, that their place is taken by a small-celled tissue, which is, however, not well preserved (Pl. 26. fig. 9, *ph.*), and with a high power it can be seen that most of the cell-walls are broken. It is interesting, however, to note that the small-celled groups corresponding to the spaces in other parts of the section are lighter in appearance than the intervening tissue, which is not generally the condition of secreting tissues.

In longitudinal section it will be seen from Pl. 23. fig. 8 that even where the large spaces have made their appearance by absorption of some of the cellular tissue, the transverse walls are still in part preserved, and show that the groups of cells were arranged in vertical series separated by transverse walls following each other at no very considerable distance.

The phloem does not form a continuous cylinder around the stem, but is broken up into numerous pieces by the leaf-trace bundles which pass out through the phloem into the cortex. This is shown in fig. 7, Pl. 24, and is also represented in the drawing, Pl. 25. fig. 13. Here it will be seen that, in passing out through the phloem, the vascular leaf-trace becomes associated with a group of phloem elements which accompany it to the outside of the stem. This phloem-tissue gets rather darker, being composed of smaller and more closely-set cells.

As will be seen in Pl. 24. figs. 7 & 12, the tissue immediately outside the phloem has been split during mineralization almost along its whole extent. This is no doubt due to the very delicate character of its cells, which are thin-walled and rectangular, and from the regular sequence of their walls appear to be of a meristematic nature. As will be seen from Pl. 25. fig. 13, which shows an enlarged view of this region, there are never many of these thin-walled cells, but generally only two or three. Such a meristem I have observed in other specimens of *Lepidophloios fuliginosus*.

A tissue of very similar appearance, but belonging to the middle cortex, is found in the stems of *Lepidodendron vasculare* (Binney), and is well figured by Scott (1900)*. In my specimen, however, this meristematic zone lies within the inner cortex, and would be morphologically identical with the pericycle, in which the appearance of meristematic cells would not be surprising. This outer meristematic layer I would compare with the meristematic zone in the pericycle of certain monocotyledons, and it could also be compared with the meristem retained in *Isoëtes*, for, according to Scott and Hill (1900), the first normal cambium on the inner side of the phloem disappears at an early period in *Isoëtes Hystrix*, and is followed by a second cambium which soon arises further to the exterior. It is of interest, with regard to the systematic position of *Isoëtes*, to find in the *Lepidodendraceæ* so distinct a secondary meristem outside the phloem.

Whether any addition to the phloem region is made from the pericyclic meristem, it was not possible to definitely ascertain in these sections, but in one or two places the arrangement of the outer phloem elements suggested such an origin.

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* Scott, D. H. (1900), fig. 54, p. 134.

Cortical Tissues.

In many parts of the transverse section we find, outside this apparently meristematic layer, a few layers of cells more or less longitudinally drawn out with black contents, and these, though not always clearly marked, have much resemblance to an endodermis. The dark cells go over into the inner cortex, of which they probably represent the inner layers, possibly specialized for storage of carbohydrate material, as is the case in those plants which possess a well-marked starch-sheath. The inner cortex as a whole is formed of a close and compact tissue, the cells of which are more or less elongated in a tangential direction and show few intercellular spaces, and seem to form a protective sheath to the stele. In longitudinal sections the cells are seen to be short and rounded.

The next portion of the cortex, the middle cortex, which is more or less clearly marked off from the inner cortex, consists of a very different tissue. Its cells are not at all closely set together, and thus leave very considerable intercellular spaces. The cells, moreover, are not all arranged with their long axis in a vertical position, but run obliquely and even horizontally, and have the appearance of a spongy parenchyma, or, when the cells are considerably drawn out, even of a felted mass of hyphæ. This trabecular cortex forms the bulk of the tissue of the stem, being 25 mm. thick in the direction of the broader diameter of the stem and 15·8 mm. in the narrower direction. Its extent is well shown in Pl. **24.** fig. 5 (*m.c.*), and the structure in Pl. **26.** fig. 15 (*m.c.*), in which it is seen in longitudinal section. Owing to the irregularity of its cells, it presents much the same appearance both in transverse and in longitudinal sections. It will be noticed that the cells are not all of the same diameter, there being larger lighter cells and smaller cells with dark contents. These latter are met with in various parts of the stem, but they are found to be very numerous and running horizontally close to the passage of the leaf-trace bundles from the middle to the outer cortex (see Pl. **26.** fig. 15). The narrower and darker cells have often an appearance not unlike a laticiferous tissue, though it is impossible in the case of a fossil plant to make this identification complete. This loose middle cortex, generally defective or absent in other *Lepidodendraceæ*, is usually well preserved in *Lepidophloios fuliginosus*, so that it is a tissue of some importance in the identification of the specimen. The demarcation between the middle cortex and the outer cortex is marked in longitudinal section (Pl. **26.** fig. 15) by the very small cells of the latter, which are drawn out tangentially and which are therefore very short in longitudinal view. An interesting feature of the longitudinal sections is the passage, in connection with each leaf-trace bundle, of a group of cells from the middle cortex through the outer cortex to the leaves, where they form the so-called parichnos. Bertrand (1891) and Hovelacque (1892) had traced the parichnos strand in *Lepidodendron* to the middle cortex, but by means of transverse sections. Unfortunately this delicate tissue is often defective in the *Lepidodendra*. But where, as in *Lep. fuliginosus*, the middle cortex is generally well preserved, the delicate parenchymatous nature of the parichnos tissue can readily be seen. It is well figured in transverse section by Binney (1872)*, and on a more enlarged scale by Seward (1900), in whose figure the hypha-like tissue can be seen. But the best longitudinal view showing the continuity between the parichnos and the middle cortex is seen on a slide (No. 796) from the specimen now under consideration, kindly lent me by Dr. Scott. Pl. **26.** fig. 15 is taken from this slide. In this figure the continuity is very well seen, as also the fact that the outer cortex runs for some distance down the leaf-trace on the upper side.

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* Binney, E. W. (1872), pl. 15. fig. 4.

Potonié's (1893) researches on the nature of the parichnos have led him to the conclusion that the parichnos running out into the leaf-base was an organ to promote active transpiration, but, from the structure of the tissue, it is quite as possible to argue that it was a respiratory organ allowing a passage of air from the leaves into the inner portion of the stem and down to the roots. Considering the structure of the roots and the supposed habitat of the plants, this would seem to me a more natural explanation. The trabecular tissue of various species of *Selaginella*, which also accompanies the leaf-traces, probably has the same function as the middle cortex and the parichnos. But the persistence of the parichnos on the leaf-scars of the old stems of *Lepidodendra* enabled them also to supply the place of the lenticels of the recent dicotyledonous trees; for stems with secondary thickening, like the recent Dicotyledons and extinct Vascular Cryptogams, would require some such organs to supply the actively growing cells of the interior with the necessary oxygen.

The cells of the outer cortex are short and closely set together, and this tissue, which is about a third of the thickness of the middle cortex (Pl. **24.** fig. 6), was no doubt largely of a protective nature and would have prevented any air from reaching the inner tissues, except where penetrated by the parichnos strands. Near the outside of the outer cortex, just on the periderm, there may be seen irregular patches of a darker colour running more or less tangentially. On closer examination it will be seen that they have the appearance of groups of secretory cells with thin walls and dark cell-contents. These are described and figured by Seward (1899) for *Lepidophloios fuliginosus* (fig. 6, p. 4 & p. 148) and also for *Lepidophloios Harcourtii* (Seward, 1900, pl. 1. fig. 3). In Pl. **24.** fig. 14 will be seen the early stages of development of this tissue, and the perfection of the preservation of these delicate tissues can be gathered from this drawing. These patches tend to become continuous in a tangential direction. An examination of this tissue is not only convincing as to their secretory nature, but also shows it to be of a very different nature from the phloem-tissue to which Seward attributes a secretory character.

Close to these secretory patches we have the secondary tissue produced from the outer cortex. As will be seen from the section shown in Pl. **24.** fig. 6, this tissue is only preserved in a portion of the section. It commences with fairly large square cells, and then near the outside the cells get smaller and more compressed. As the outer portion of the tissue is much disorganized it is impossible to distinguish an actual phellogen. In all probability this tissue will be morphologically a phelloderm with a phellogen on the outside; but the appearance of its cells, both in transverse and longitudinal section, suggests a function agreeing more with that of true cork. In longitudinal view the cells are seen to be much more elongate than the cortical cells and arranged in fairly close alternating series.

Leaf-traces.

The giving off of the leaf-traces from the primary wood was described in connection with that tissue. The mesarch bundles thus given off pass nearly vertically at first through the ground-tissue and the secondary elements lying between the xylem and phloem. This portion of their course is seen in Pl. 25. fig. 11. As they pass out through the phloem (Pl. 25. fig. 13) they carry outwards a portion of the phloem, which always remains separated from the xylem elements by a few rows of undifferentiated cells. In passing through the inner cortex the leaf-traces still retain their steeply inclined position, but when they reach the middle cortex (see Pl. 24. fig. 6) they become much more horizontal in position. This is more particularly the case with the leaf-traces passing in the direction of the longer diameter of the stem. These very oblique or horizontal leaf-traces in this region are very characteristic of most specimens of *Lepidophloios fuliginosus* in the Manchester Museum, and are not generally so found in other *Lepidodendraceæ*. An examination of the bundles whilst running through this middle cortex will show that they are surrounded by a firm sheath of cells, similar to those of the inner cortex through which the bundle has previously passed.

The course of the leaf-traces through the outer cortex is much the same as that in the middle cortex, and here too it is quite horizontal.

As the leaf-cushions are absent, we cannot follow the leaf-traces beyond this layer.

Branching of the Stele.

The branching of the stele to supply the halonial tubercle agrees in all respects with the cases described by Williamson (1873), (1881), (1893). The stele does not divide equally as in the case of ordinary branching, but displays a somewhat horseshoe-shaped segment in the case of halonial branches with two rows of tubercles at the two ends of the longer axis of the elliptical stele. This is well figured by Williamson (1881) for *Lepidophloios fuliginosus* (pl. 52. fig. 9), and is also seen in our figure of the transverse section of *Lepidophloios fuliginosus* (Pl. 24. figs. 6 & 7). In this specimen of *Lepidophloios*, however, the branch of the stele takes, like the leaf-trace bundles, a more horizontal course soon after separating from the central stele, so as to be seen more horizontally in subsequent sections where it is nearer the outside. This very oblique course gives us a less clear picture in the transverse sections, while longitudinal sections, such as that figured by Williamson (1893) (pl. 2. fig. 25), give us a better idea both of the course and of the structure of this stelar branch.

The commencement of the branching of the stele is characterized by the breaking up of the cylinder of primary xylem by intruding bands of medullary tissue. At the same time a corresponding piece of phloem is separated off by strands of cortical cells, which ultimately meet the projections from the pith.

The horseshoe-shaped piece of primary wood which is thus detached gives off numerous leaf-traces on the outside, as can be seen in Pl. 24. fig. 7. The gap in the stele becomes bridged over by a tissue the cells of which have dark contents, and which appears continuous with what I have described above as a possible endodermis. A similar dark sheath forms around the stelar branch, which at a little distance from the main stele becomes clothed on the inside, too, with a layer of phloem-cells. At first the branch is destitute of pith, but a little way from the main stele a more or less definite medullary tissue of parenchymatous nature can be observed both in the radial longitudinal sections through the tubercle and also in transverse sections of it (tangential to the main axis). In sections of this latter kind, the appearance of the stelar branch is very much like that figured by Williamson (1881) (fig. 12, pl. 51).

The arrangement of the xylem around the pith (Pl. 25. fig. 19) is more or less radial, but has not the definite character of the stele in the peduncle of *Cheirostrobus*, *Spencerites*, or *Lepidostrobus* as described by Scott (1897 & 1898), Bower (1893), and Maslen (1899).

Outside the xylem we find a dark layer of small parenchymatous cells in which numerous leaf-traces are embedded. Then comes a very definite band of more lightly-coloured cells, rectangular in shape, with their long axis in a radial direction. This layer of cells is exactly similar to that found within the phloem of the main axis, where it apparently separates the phloem from the cambium.

Beyond this very definite layer of cells lie groups of phloem interrupted by leaf-trace bundles showing a very clear mesarch arrangement of their xylems (Pl. 26. fig. 18). As these leaf-traces pass outwards through the phloem, they carry with them some of the phloem-tissue, which generally appears considerably compressed. The phloem groups, however, which alternate with the xylem often show their structure very clearly, though some groups are more or less disorganized. Those which are best preserved exhibit in transverse section a number of large and clear polygonal cells, between which are here and there smaller and darker cells. Their appearance is therefore not unlike that of the phloem of recent Lycopodiales. In longitudinal section, however, where they can be easily recognized by their position and their size, the phloem-cells will be found to be short and rectangular, their length being about the same as that of the cells of the cortical sheath immediately outside. The width of the phloem-cells, however, is greater than that of the cortical cells. In longitudinal section these phloem-cells differ considerably from the phloem of recent Lycopodiales, except possibly *Isoëtes*, and they differ also from the phloem-cells described by Maslen (1899) in *Lepidostrobus*. In none of the groups of phloem in the stelar branch could I find any of those divisions which are found in the phloem-cells of the main axis (see fig. 9, Pl. 26). But I have pointed out, in connection with the phloem of *Lepidophloios* (1901), that in the leaf-trace bundles, too, there is an absence of these longitudinal divisions of the phloem-cells.

The stelar branch, on its way to the tubercle, is always surrounded by a sheath of dense cells continuous with the inner cortex which surrounds the main stele, and from its very commencement it gives off leaf-traces which can be seen cut transversely in this inner cortical sheath. Even when these leaf-traces pass out into the mid-cortex, they remain much more parallel to the stelar branch than is the case with the leaf-traces given off from the main stele.

In passing into the outer cortex, the stelar branch retains a fairly thick sheath of tissue continuous with the middle cortex, which can be seen in the transverse section of the stem (Pl. 26. fig. 16) and also in a section passing transversely through the base of the tubercle (Pl. 26. fig. 17). This middle cortex is of the same nature as that of the main axis, but is remarkable for the great distinctness of the two kinds of cells described above, the smaller denser ones accompanying the stelar branch very much in the same way as they do the leaf-traces (see Pl. 26. fig. 16). In one or two places I have observed at the demarcation between the middle and the outer cortex a group of cells of the former showing an arrangement which indicated a certain amount of meristematic activity of the outermost part of the middle cortex. A similar phenomenon I have described (1901) in a rootlet which I consider belonged probably to *Lepidophloios fuliginosus.*

Whether or not the stelar branch supplied a strobilus cannot be determined from the present specimen. I have, however, pointed out above one or two points in which it diverges from the structure described for the peduncles of various lepidodendroid strobili.

The anatomical characters of the main axis, however, as described above leave, I think, no room for doubt that this halonial branch belonged to the plant now known as *Lepidophloios fuliginosus.*

The most important points in the structure of the halonial branch which support this identification are:—

(1) The parenchymatous pith and the general arrangement of the primary xylem.

(2) The very characteristic mode of secondary growth resulting in the almost exclusive formation of parenchymatous cells.

(3) The well-preserved middle cortex and its peculiar structure.

(4) The secretory tissue of the outer cortex.

These special points in which the plant differs from one or other of the various *Lepidodendraceæ* are, I think, sufficiently characteristic to confirm the identification made by Dr. Scott (1898).

On anatomical grounds, then, we may describe the specimen under consideration as a branch of *Lepidophloios fuliginosus.* The halonial branches of this species are generally of the multiseriate type, *i. e.* with a quincuncial arrangement of the tubercles. I have, however, pointed out in the first part of this paper that this was by no means always the case. Williamson has described specimens of *Lepidophloios* which could be recognized both by their internal structure and by their leaves, and also possessed two rows of tubercles. Similarly, in the first part of this paper, I have described specimens, both from the British Museum and from the Manchester Museum, which, to my mind, must be classed as *Lepidophloios* and which possess only two rows of tubercles.

There seems, therefore, to be no reason why the specimen under consideration should not be correctly described as a biseriate halonial branch of *Lepidophloios fuliginosus.*

[Postscript, *November* 20, 1902.—The specimen forming the subject of this Memoir, together with a number of sections cut from it, has been deposited in the Manchester Museum, Owens College.—F. E. W.]

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EXPLANATION OF PLATES 23–26.

Pl. **23**. fig. 1. Photograph (nat. size) of the halonial branch of *Lepidophloios fuliginosus*, showing the two rows of tubercles. Near the upper and lower ends the periderm is preserved; where the latter is absent, the leaf-traces are seen forming small elevations in the cortical tissues.

The photograph is by Messrs. Gunn & Stuart, of Richmond.

Pl. **23**. fig. 2. Photograph ($\frac{2}{3}$ nat. size) of an halonial branch in the Manchester Museum, from the Four Foot Mine at Tonge, near Bolton. One of the two rows of tubercles is here visible, but no remains of the leaf-bases.

Pl. **23**. fig. 3. Photograph of the other side of the halonial branch depicted in fig. 2, showing the other row of tubercles, and near the top right-hand side the traces of bifurcation. On this side are seen the carbonized remains of the leaf-bases, showing that these were of the *Lepidophloios*-type.

Pl. **23**. fig. 4. A portion of the leaf-bases of the halonial stem illustrated in figs. 2 & 3, somewhat enlarged to show the downward imbrication of the leaves.

Pl. **24**. fig. 5. Photograph of an halonial branch from the Williamson Collection (British Museum), cabinet-number 1946 B, showing imbricating leaf-bases and two rows of tubercles.

Pl. **24**. fig. 6. Transverse section (slightly enlarged) of the halonial branch of *Lepidophloios* described in this Memoir, showing the general arrangement of tissues. The stele is interrupted, having just given off a branch (*b*) to one of the tubercles.

i.c. = inner cortex.
m.c. = the middle cortex, with horizontal leaf-trace bundles.
o.c. = outer cortex.
per. = periderm.

Pl. **24**. fig. 7. Enlarged view of stele of halonial branch.

m. = medulla.
p.x. = primary xylem.
s.t. = secondary tissues.
ph. = phloem.
i.c. = inner cortex, with leaf-traces.
b. = vascular branch.

Pl. **23**. fig. 8. Portion of phloem in longitudinal section, showing transverse walls (*tr.w.*) across the lacunæ formed by a breaking down of the phloem-cells.

Pl. **26**. fig. 9. Portion of transverse section, showing phloem-area (*ph.*) occupied by small-celled tissue, before decay of latter.

Pl. **25**. fig. 10. Longitudinal section through outer portion of medullary tissue (*m.*), showing the division of its elongated cells by transverse and oblique walls. The inner pith-cells on the left-hand side are much compressed.

p.x. = scalariform tracheids of primary xylem.

Pl. **25**. fig. 11. Longitudinal section of a portion of the stele in which there has been a considerable amount of secondary tissue formed (*s.t.*), showing its short-celled character.

l.t. = leaf-trace.
ph. = phloem.
i.c. = inner cortex.
p.x. = primary xylem.

Pl. **24**. fig. 12. Transverse section through secondary tissues (*s.t.*), consisting of small square cells. Lettering as in fig. 11. *sp.*, split in tissues in the region of the pericycle; this is also seen in fig. 7.

Pl. **25**. fig. 13. Drawing of portion of transverse section representing the outward passage of mesarch leaf-trace (*l.t.*) through the phloem region.

ph. = phloem partially disorganized.
ph'. = phloem group which will accompany leaf-trace bundle.
c.t. = columnar tissue, possibly of meristematic nature or immediately outside the cambium and the secondary tissues.
per. = pericycle, in part meristematic, on left-hand side.
i.c. = inner cortex.

Pl. **24**. fig. 14. Longitudinal view of the secretory tissue found immediately on the inside of the periderm. In the lower part of the drawing its mode of origin from the outer cortex is recognizable.

o.c. = outer cortex.
sc. = secretory tissue.

Pl. **26**. fig. 15. Portion of a longitudinal section from Dr. Scott's cabinet (No. 796), showing the origin of parichnos (*par.*) as a continuation of the middle cortex (*m.c.*) accompanying the leaf-trace bundle (*l.t.*) in its course through the outer cortex (*o.c.*).

Pl. **26**. fig. 16. Portion of a transverse section of halonial branch a little above the one represented in fig. 7, showing stele closed again after having given off bundle and the vascular branch to the tubercle running nearly horizontally through middle cortex and outer cortex.

v.b. = vascular branch to tubercle.
m.c. = middle cortex.
o.c. = outer cortex.

Pl. **26**. fig. 17. Tangential section through halonial stem near tubercle, showing the vascular branch surrounded by sheath of middle cortex (*m.c.*) making its way through the outer cortex (*o.c.*).

per. = periderm.

Pl. **26**. fig. 18. Drawing of portion of stele of the halonial tubercle seen in transverse section, showing one of the mesarch leaf-traces (*l.tr.*) passing outwards to the phloem (*ph.*).

c.t. = columnar tissue lying between the xylem and phloem.

Pl. **25**. fig. 19. More enlarged view of the stele of the halonial tubercle, showing the somewhat irregularly arranged tracheids of the wood surrounding the parenchymatous pith.

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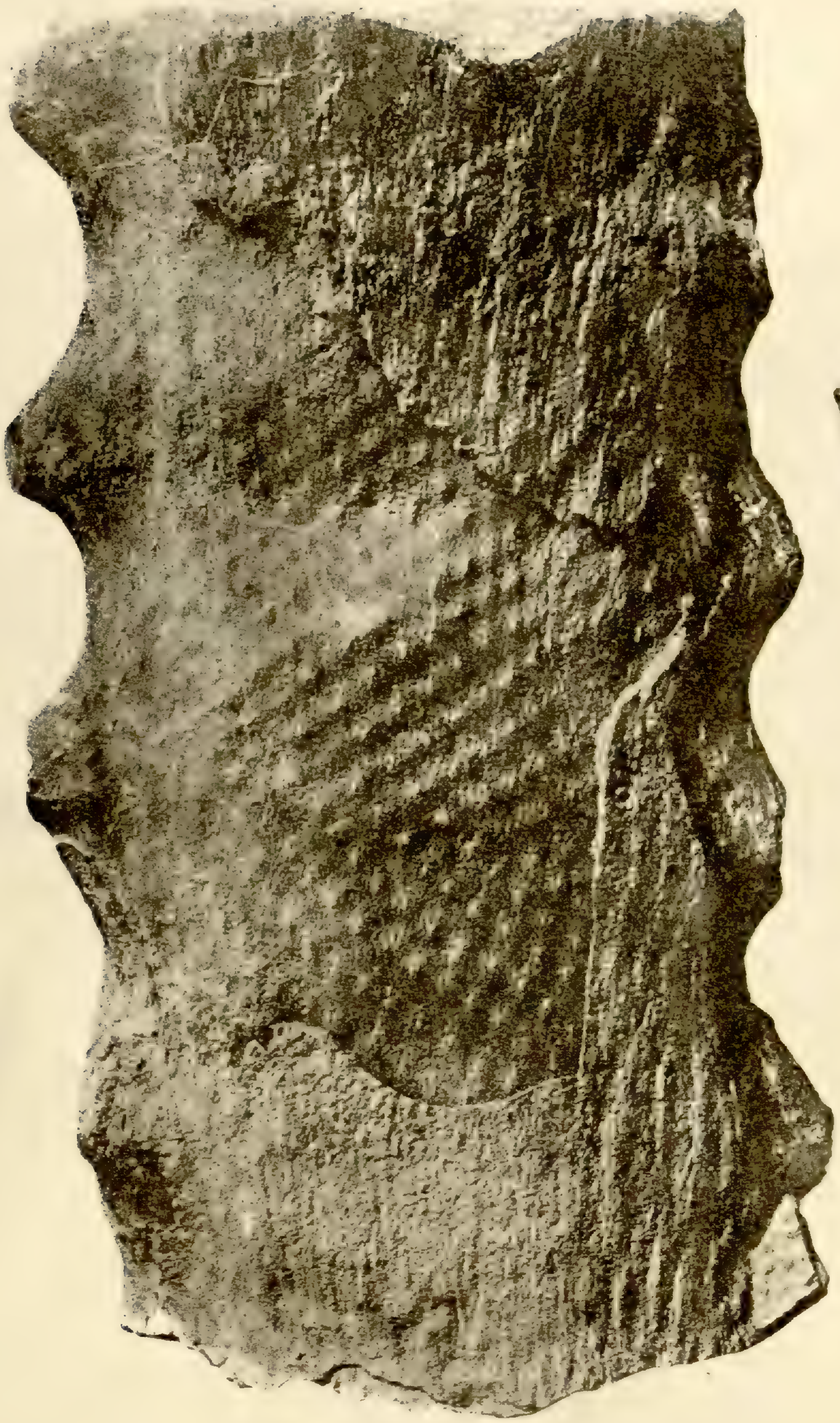

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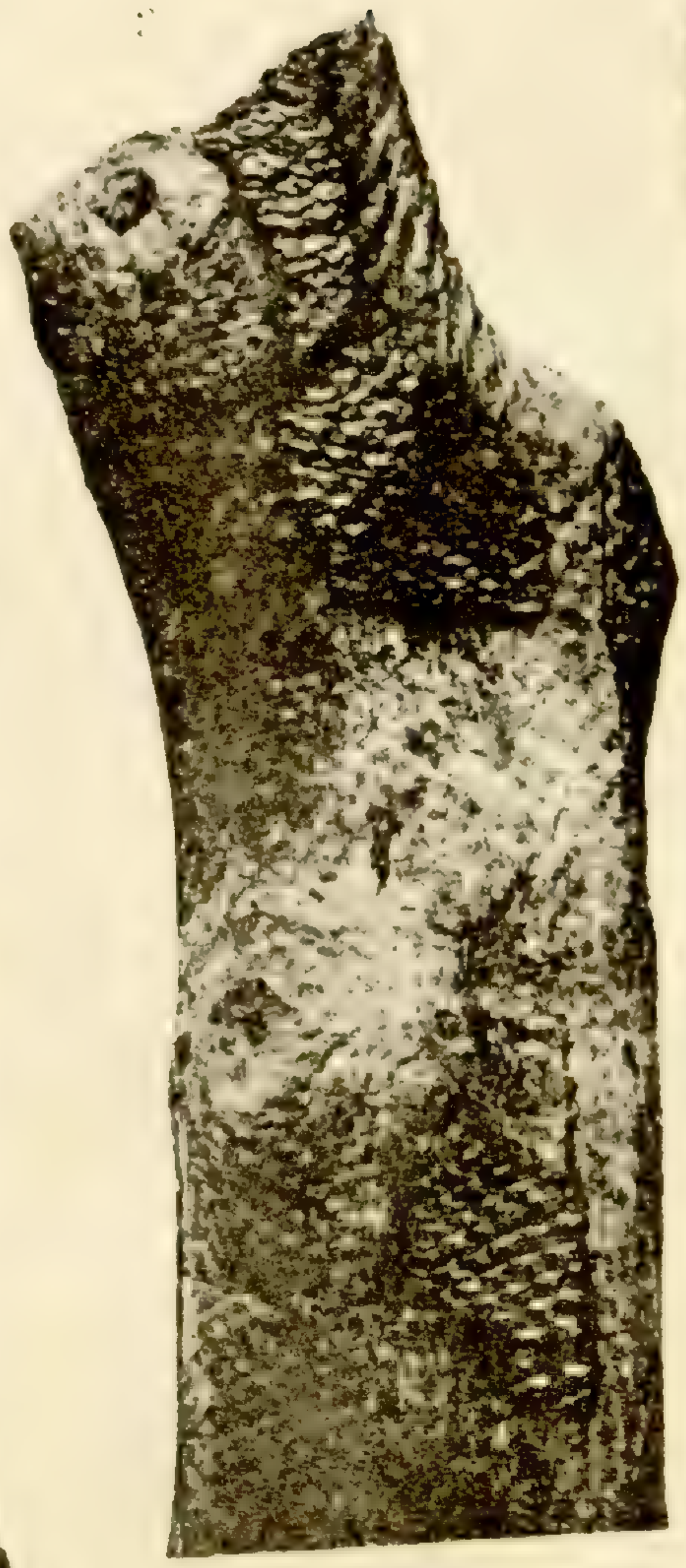

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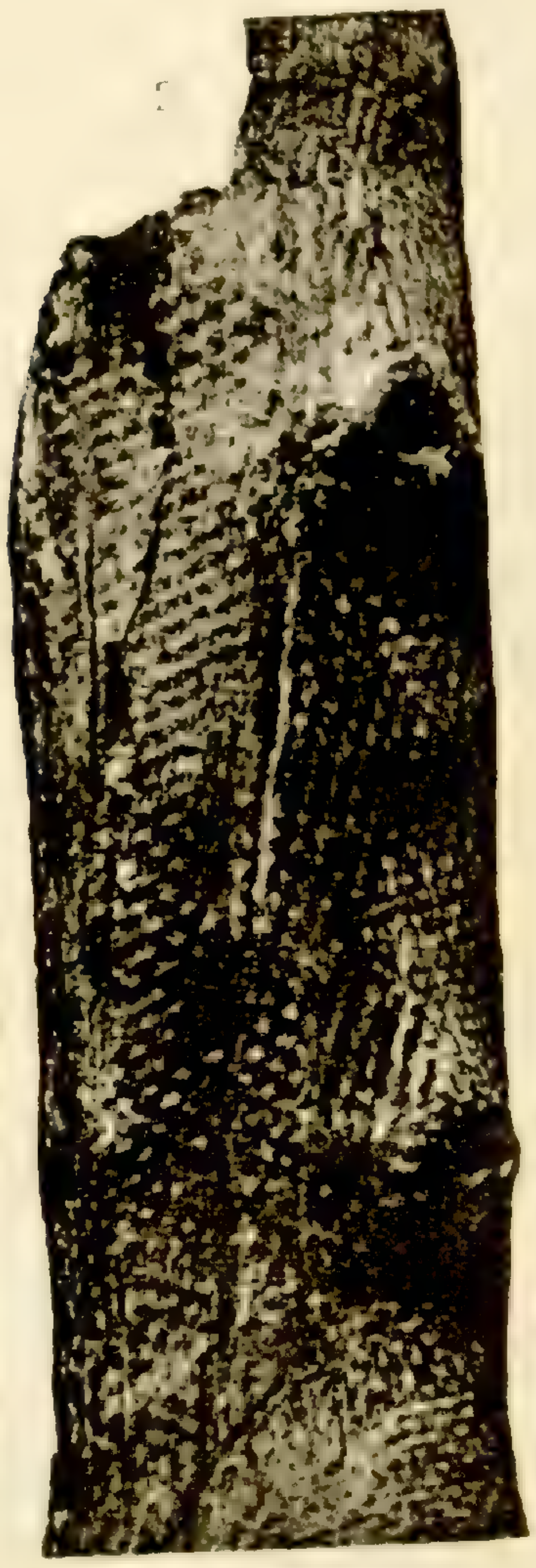

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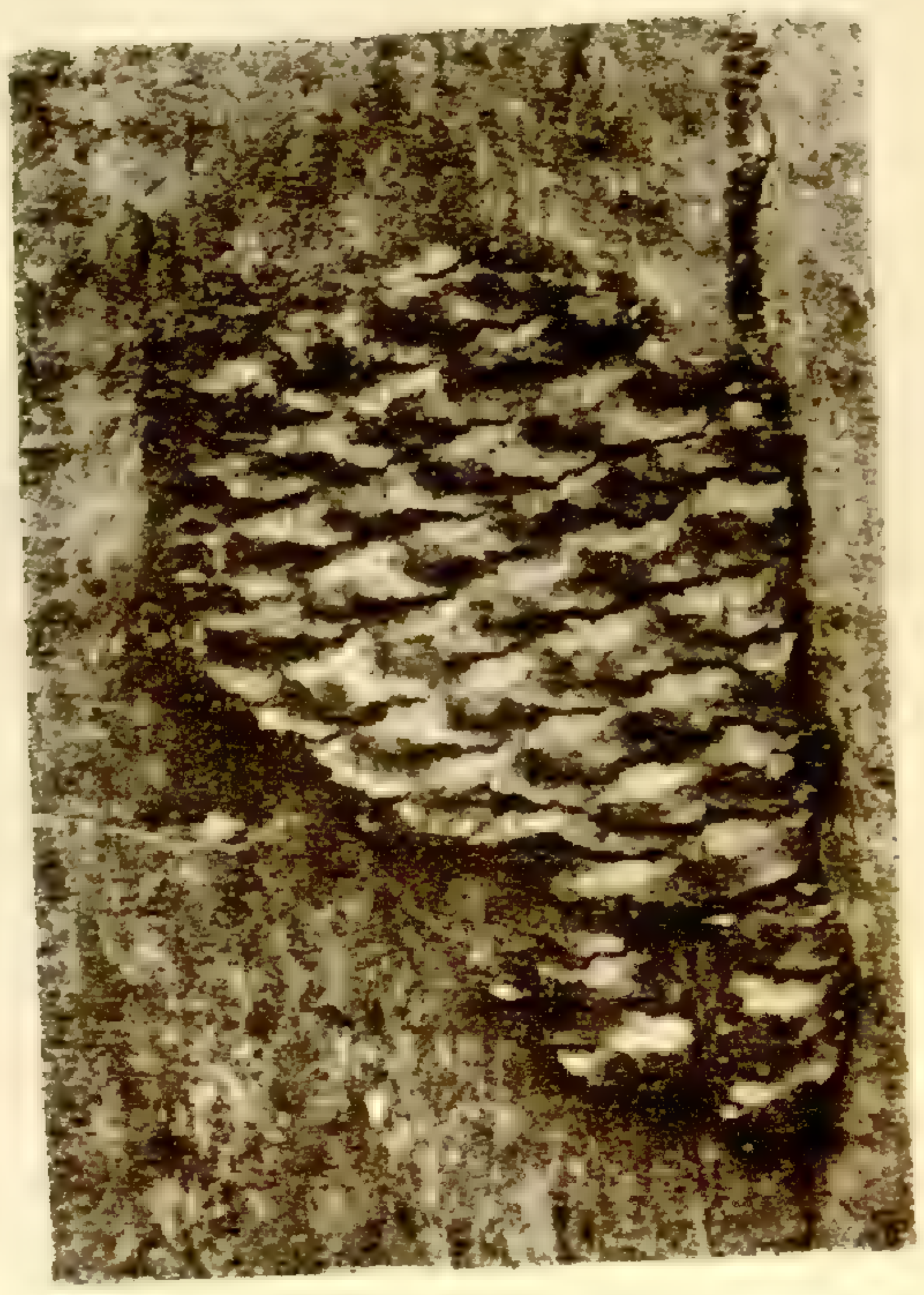

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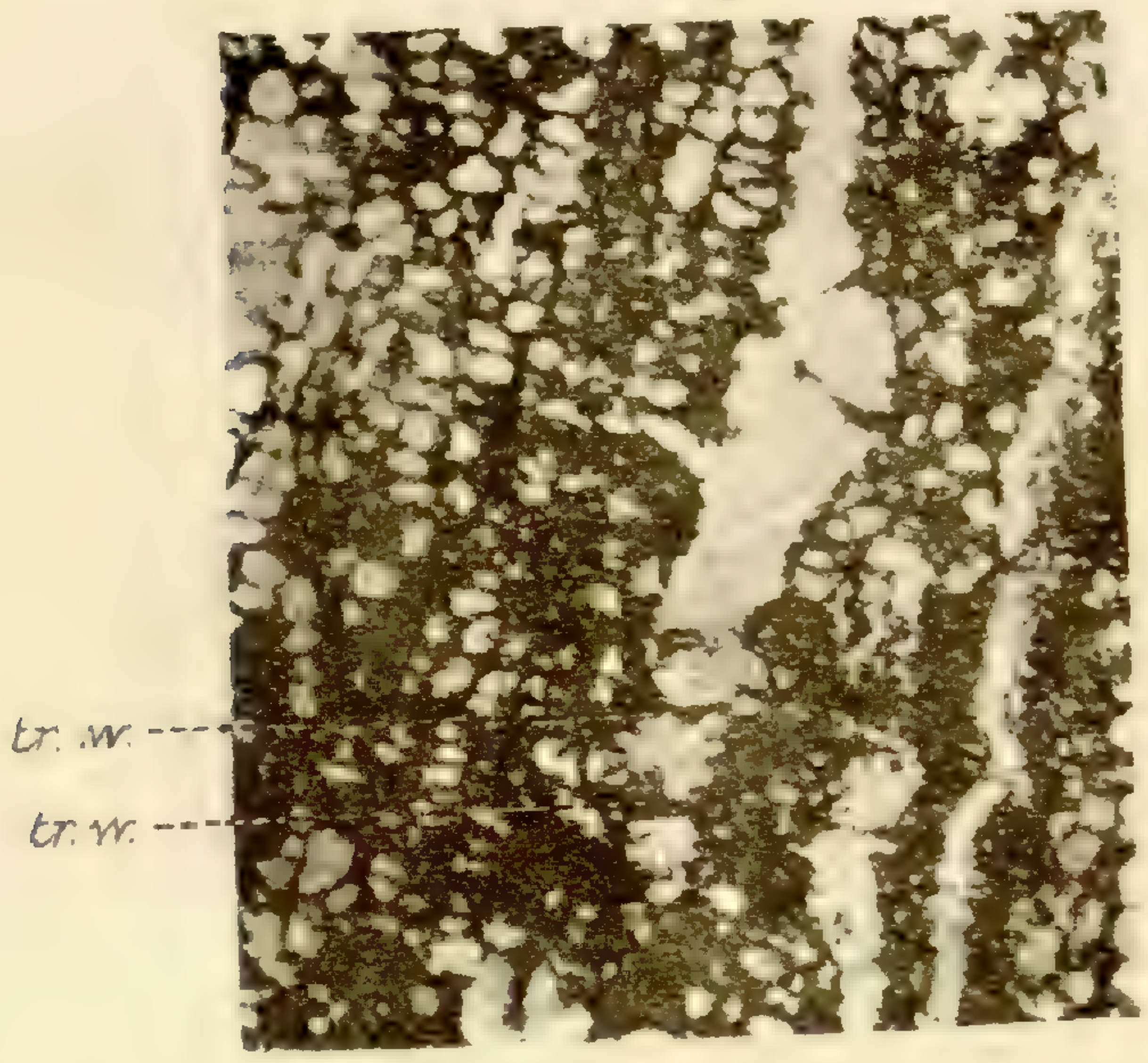

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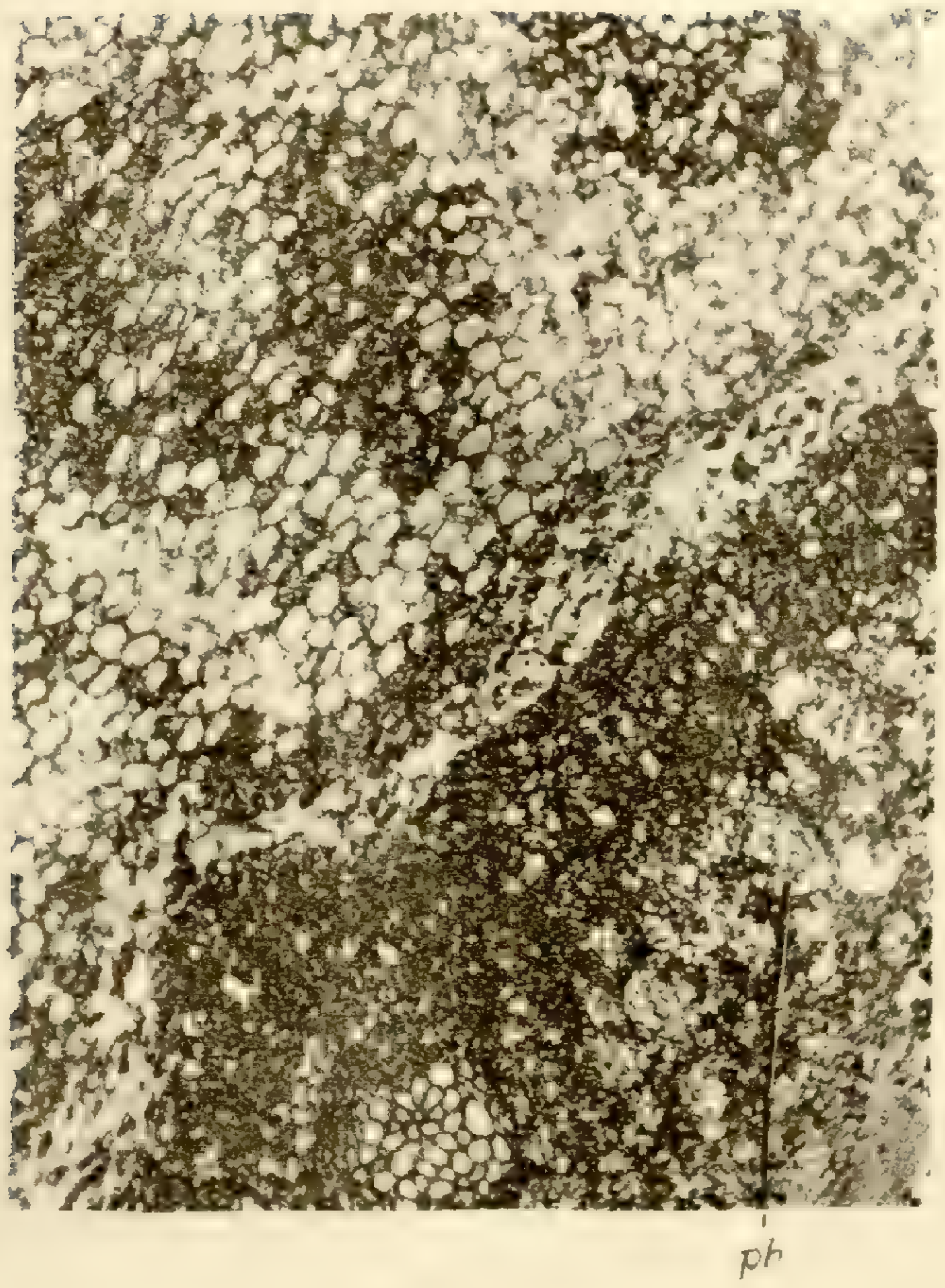

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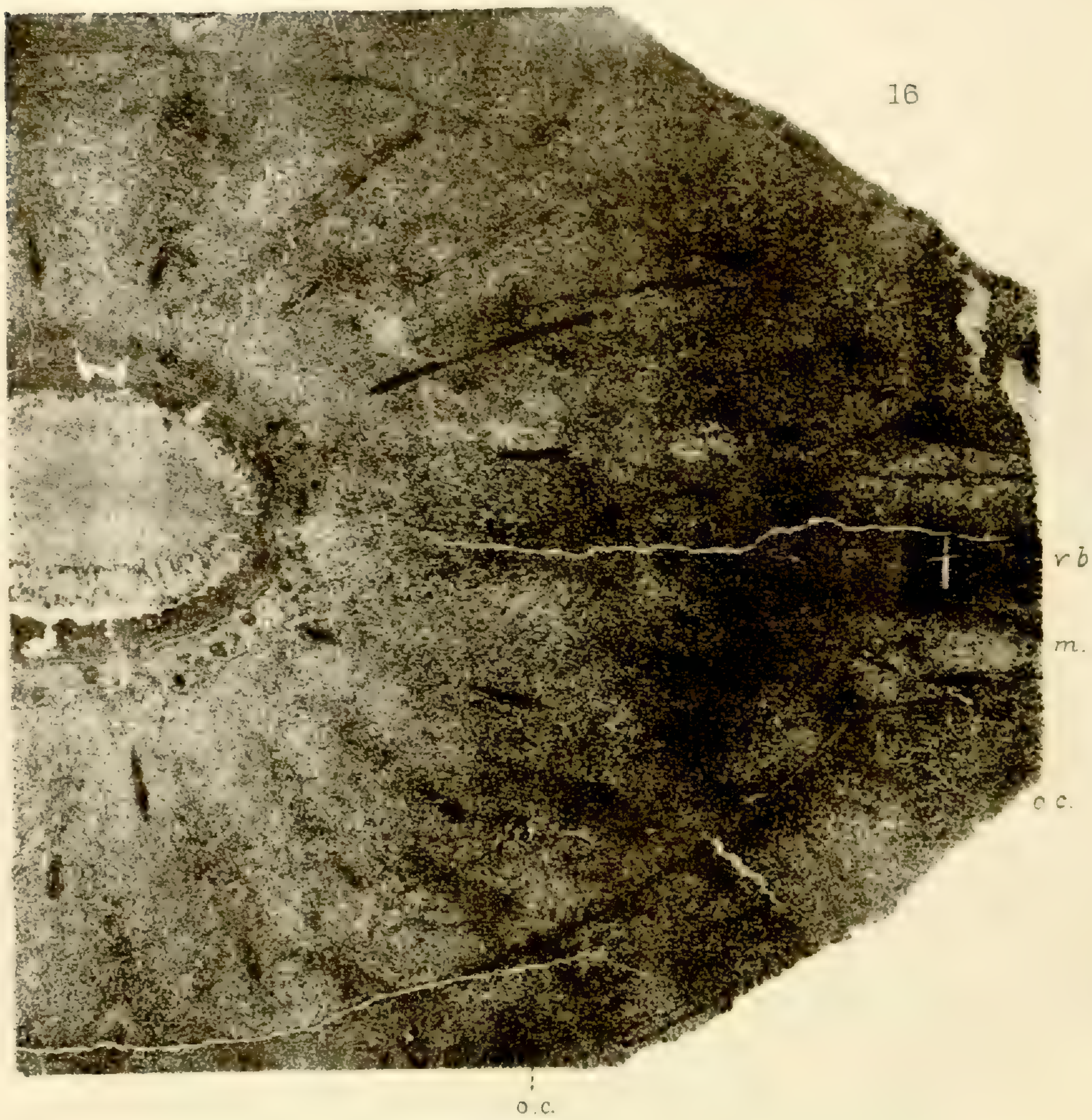

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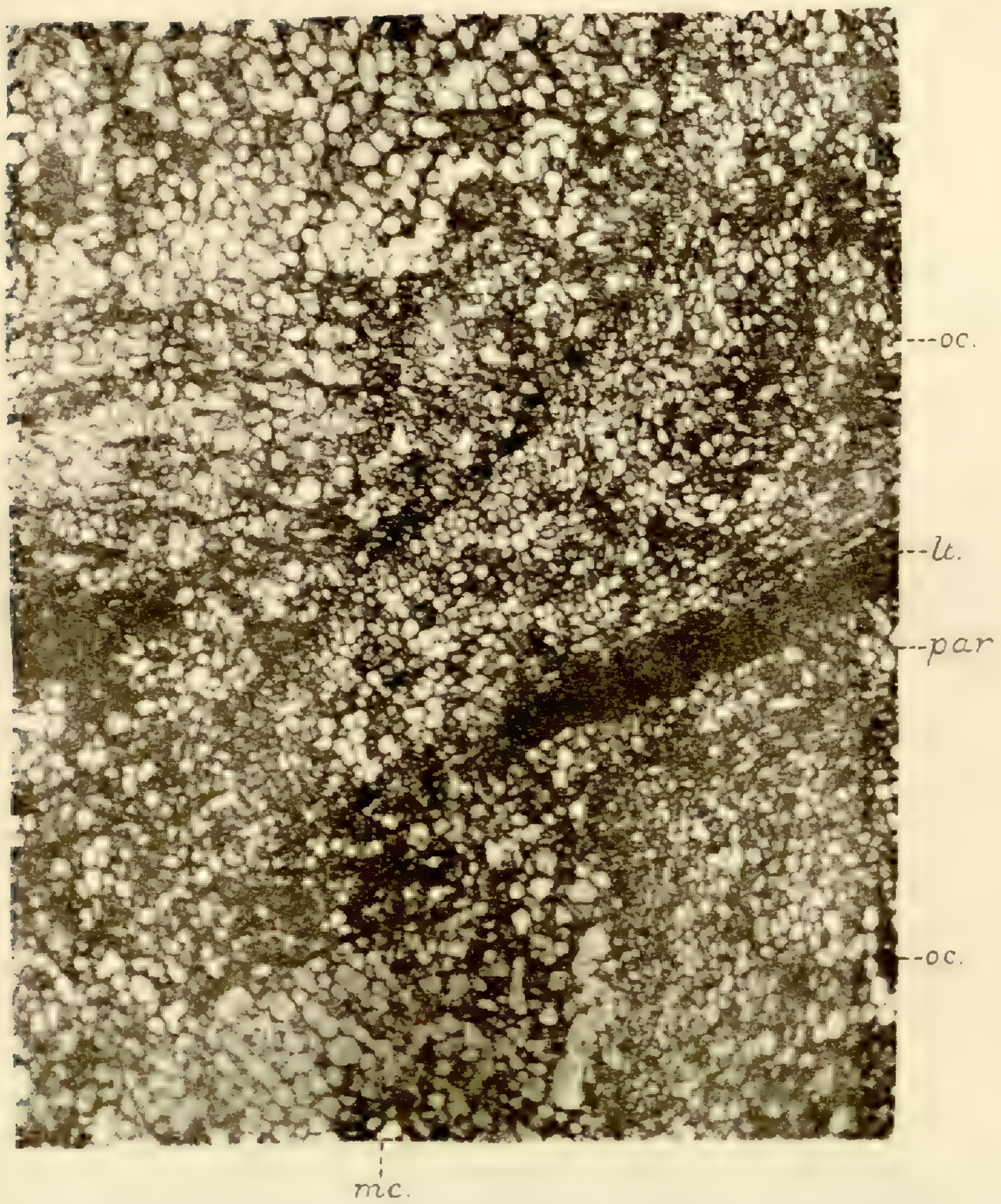
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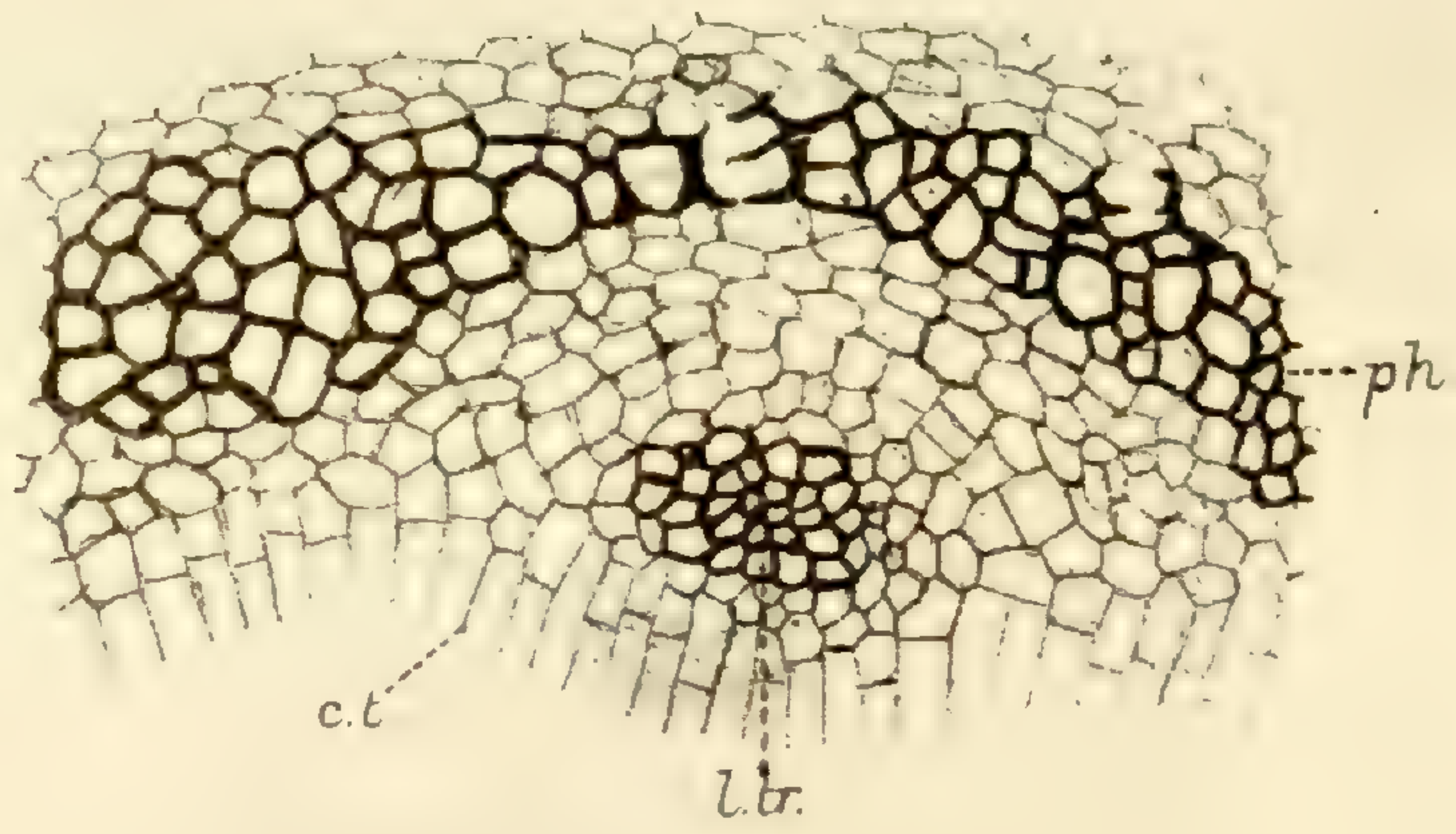

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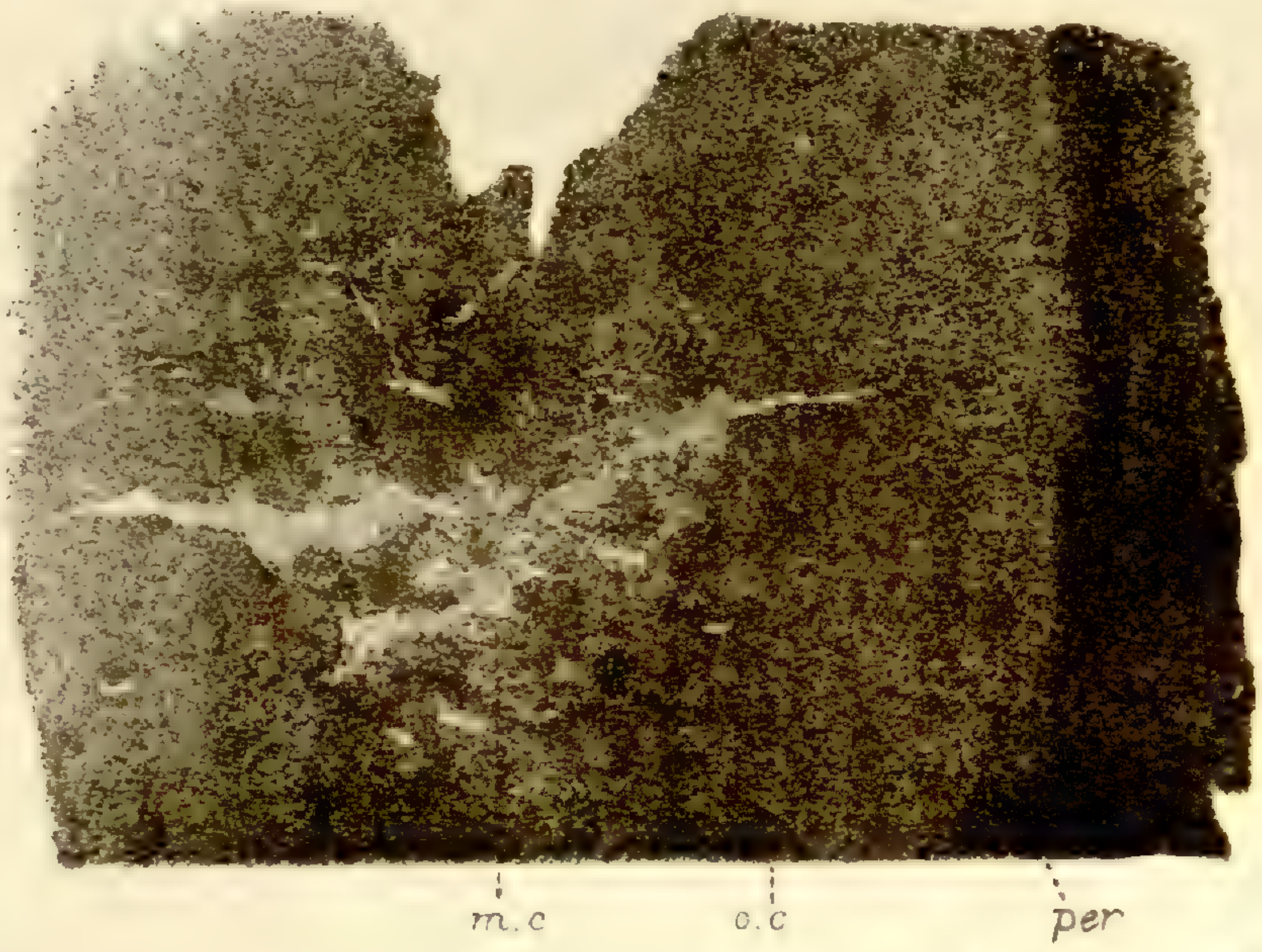

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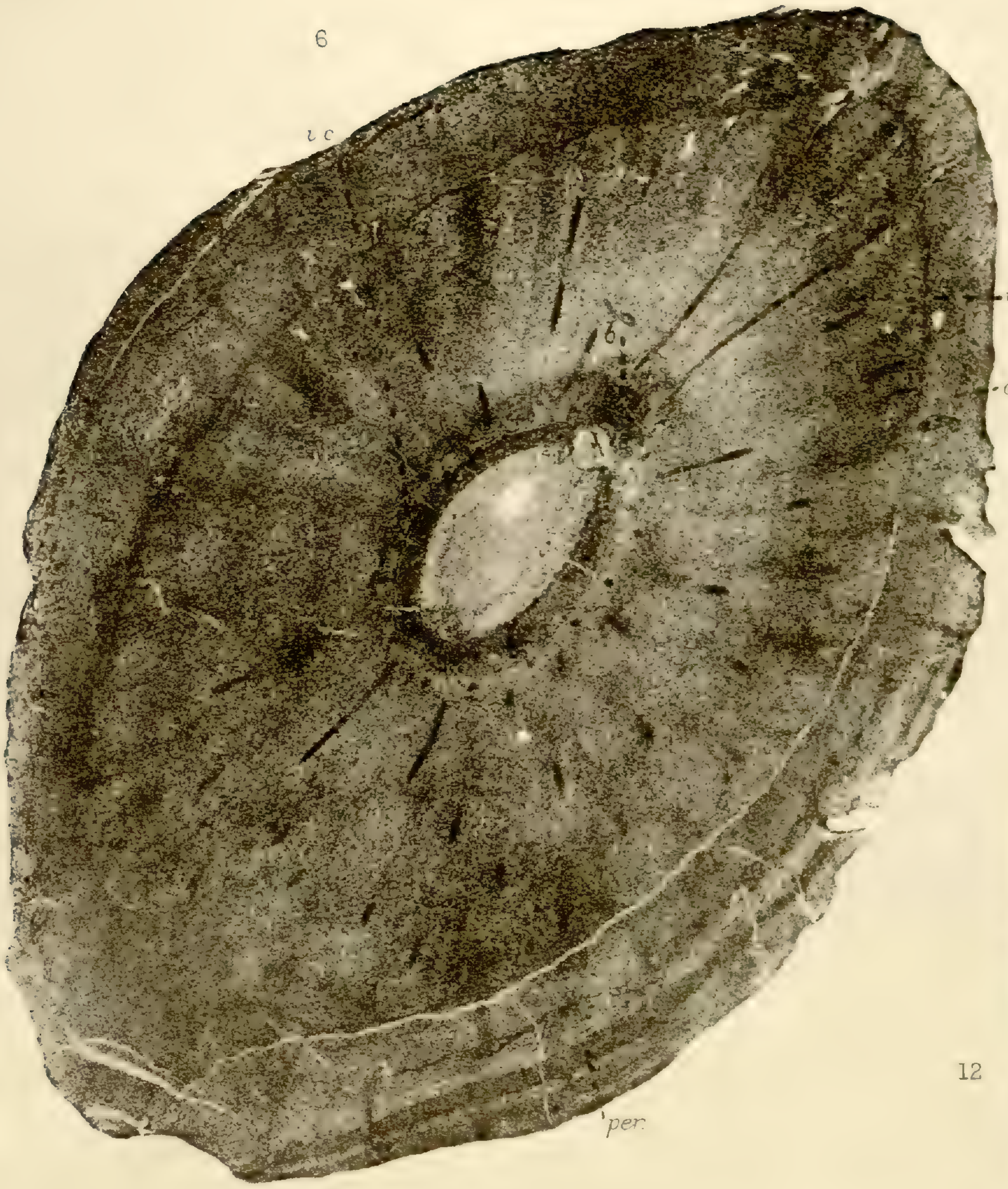
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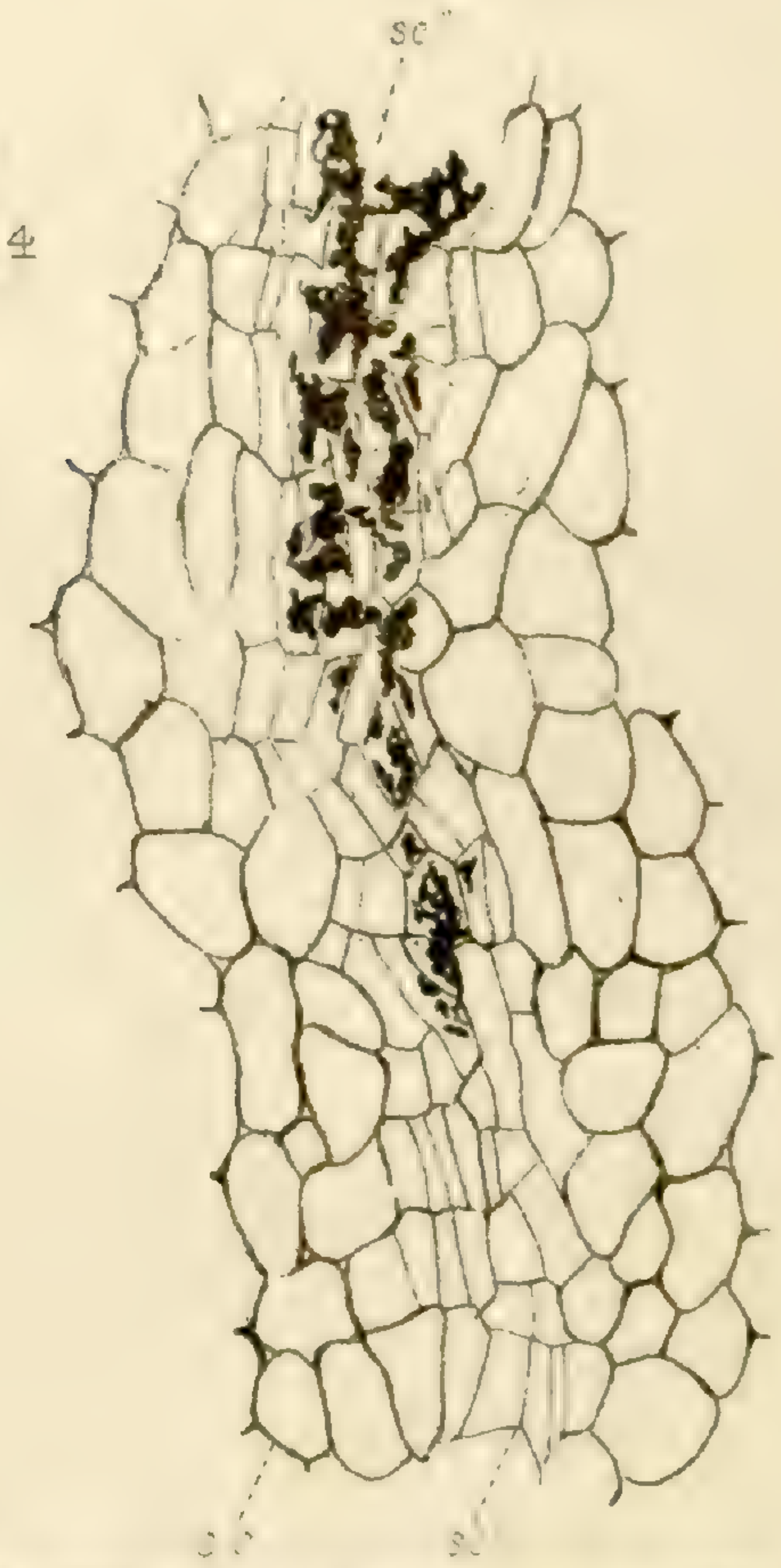

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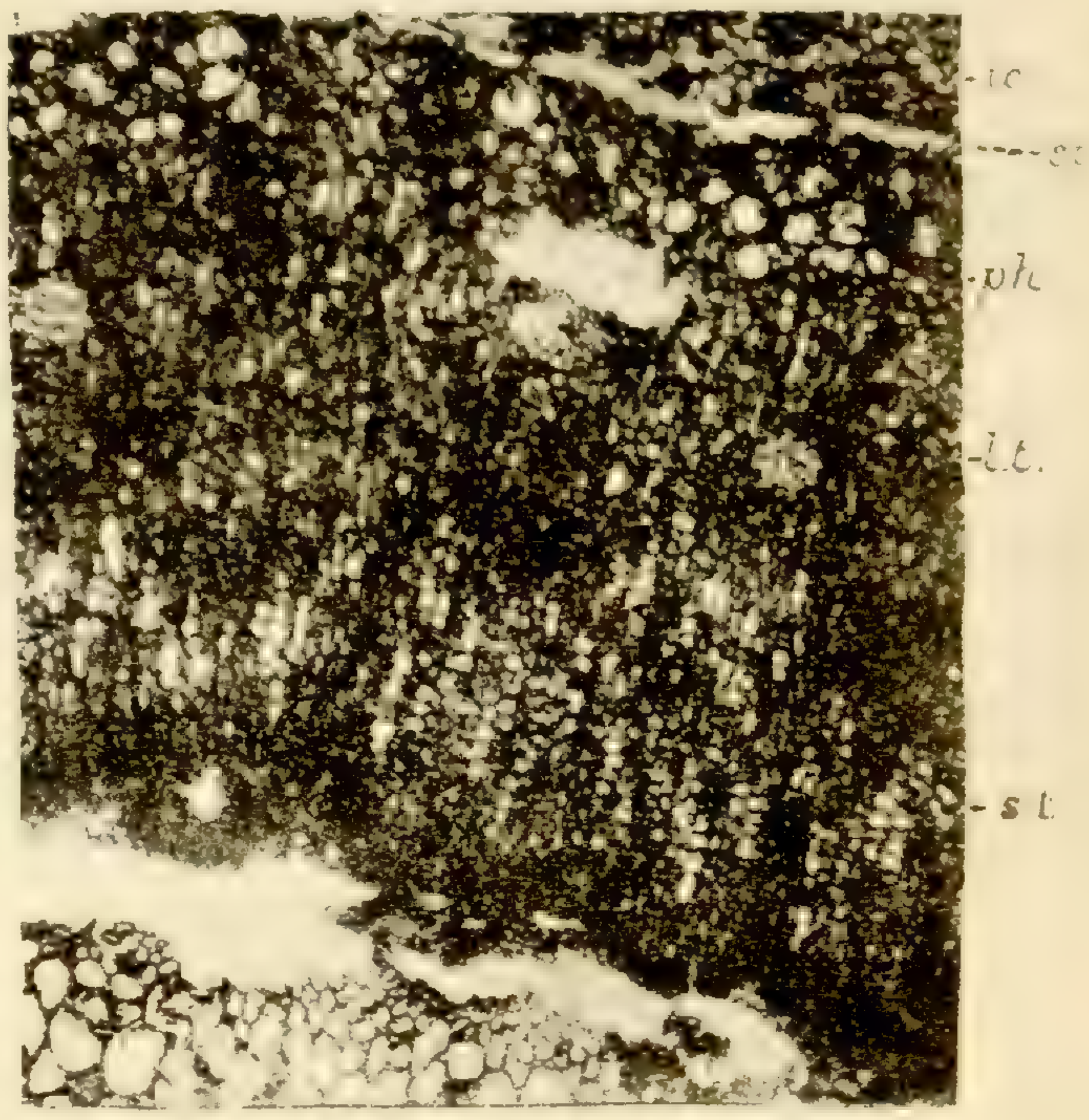
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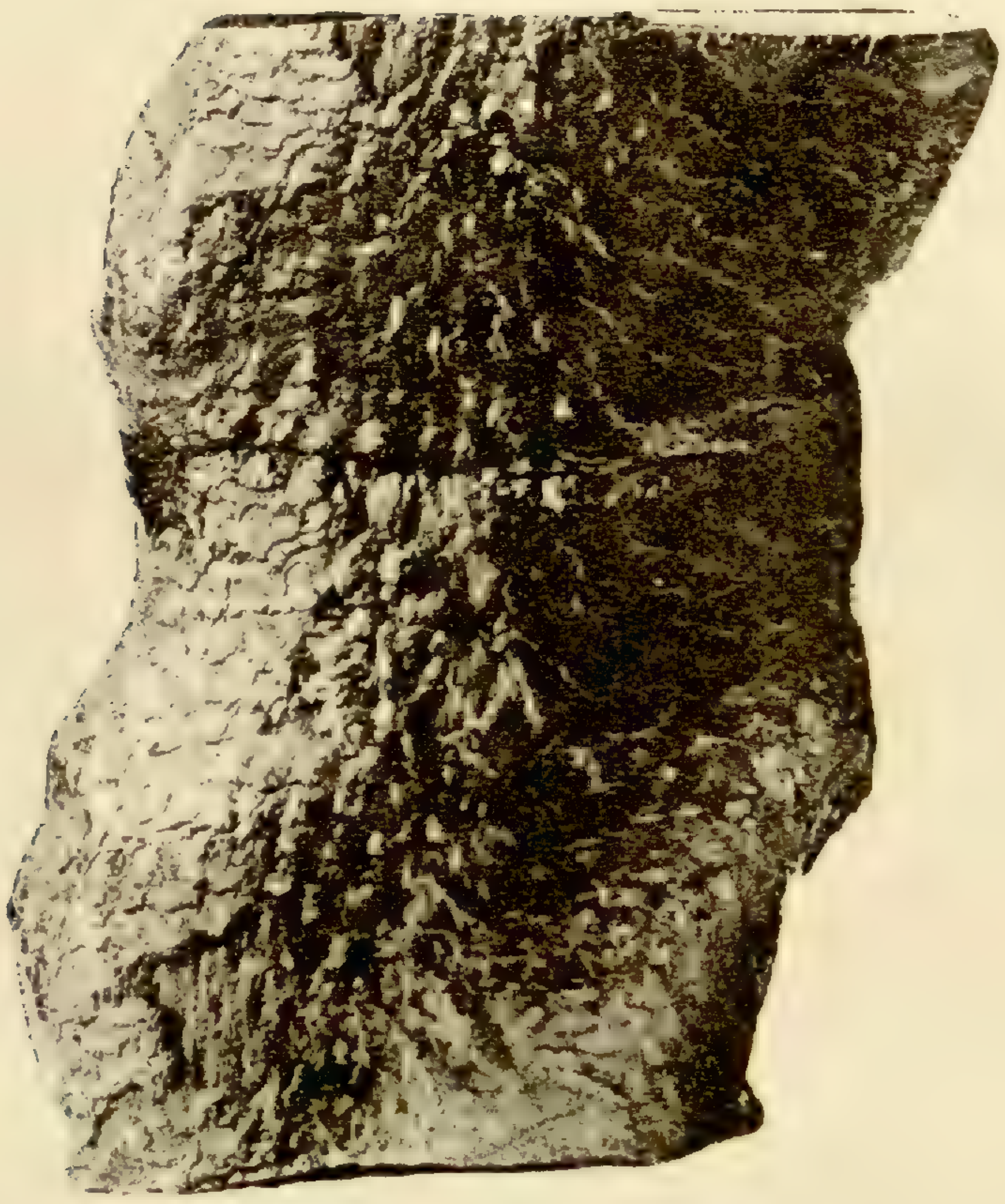

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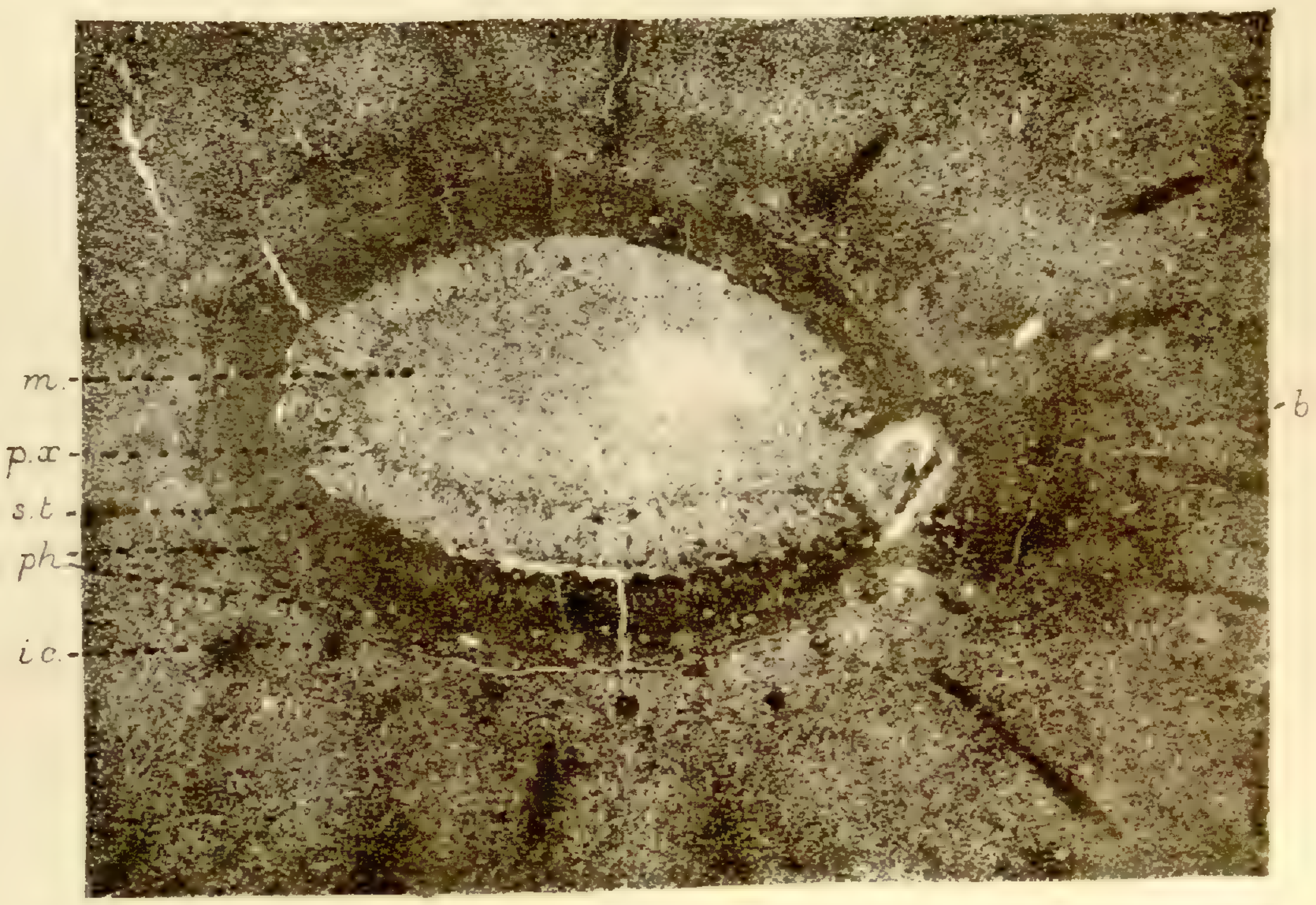
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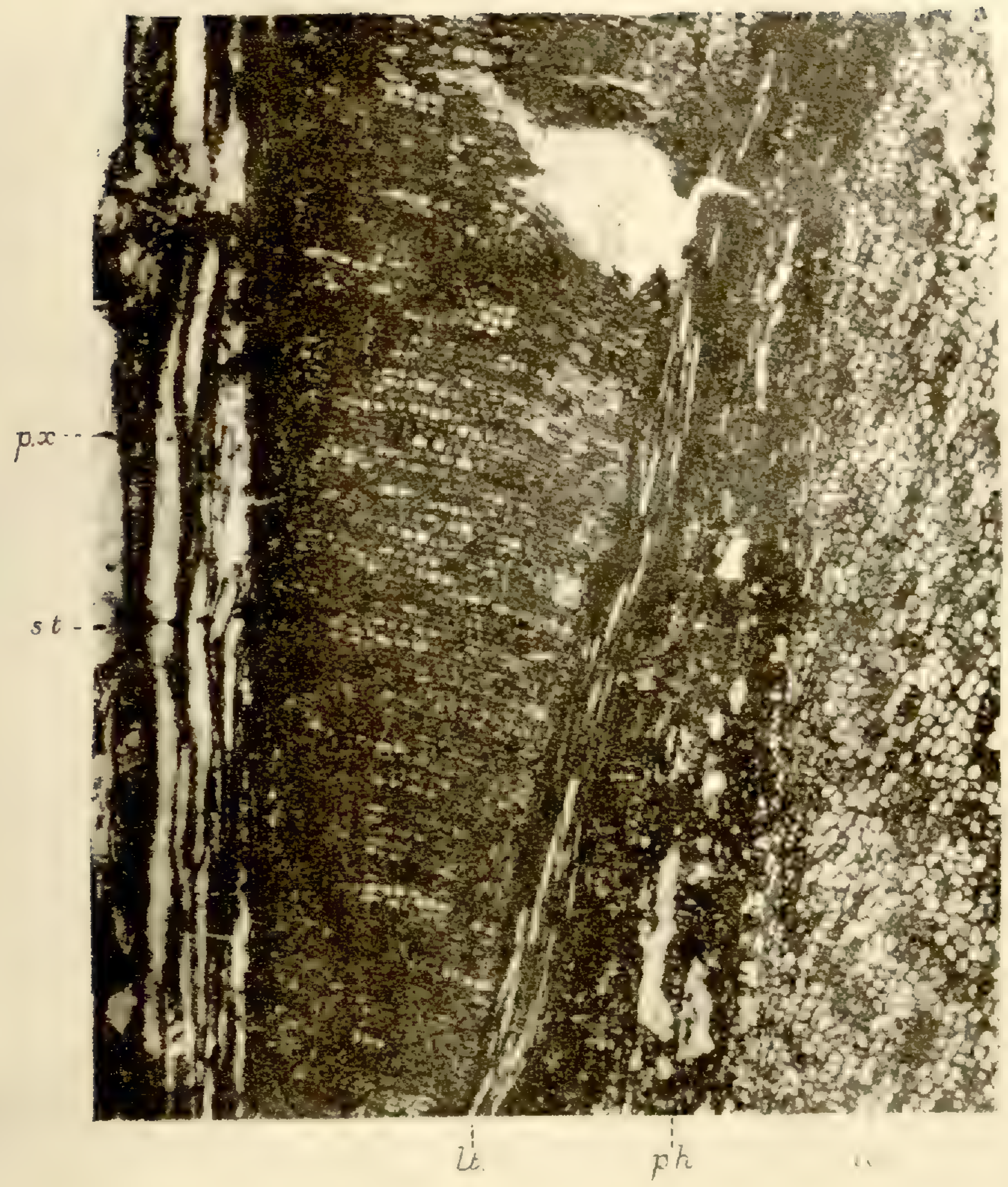

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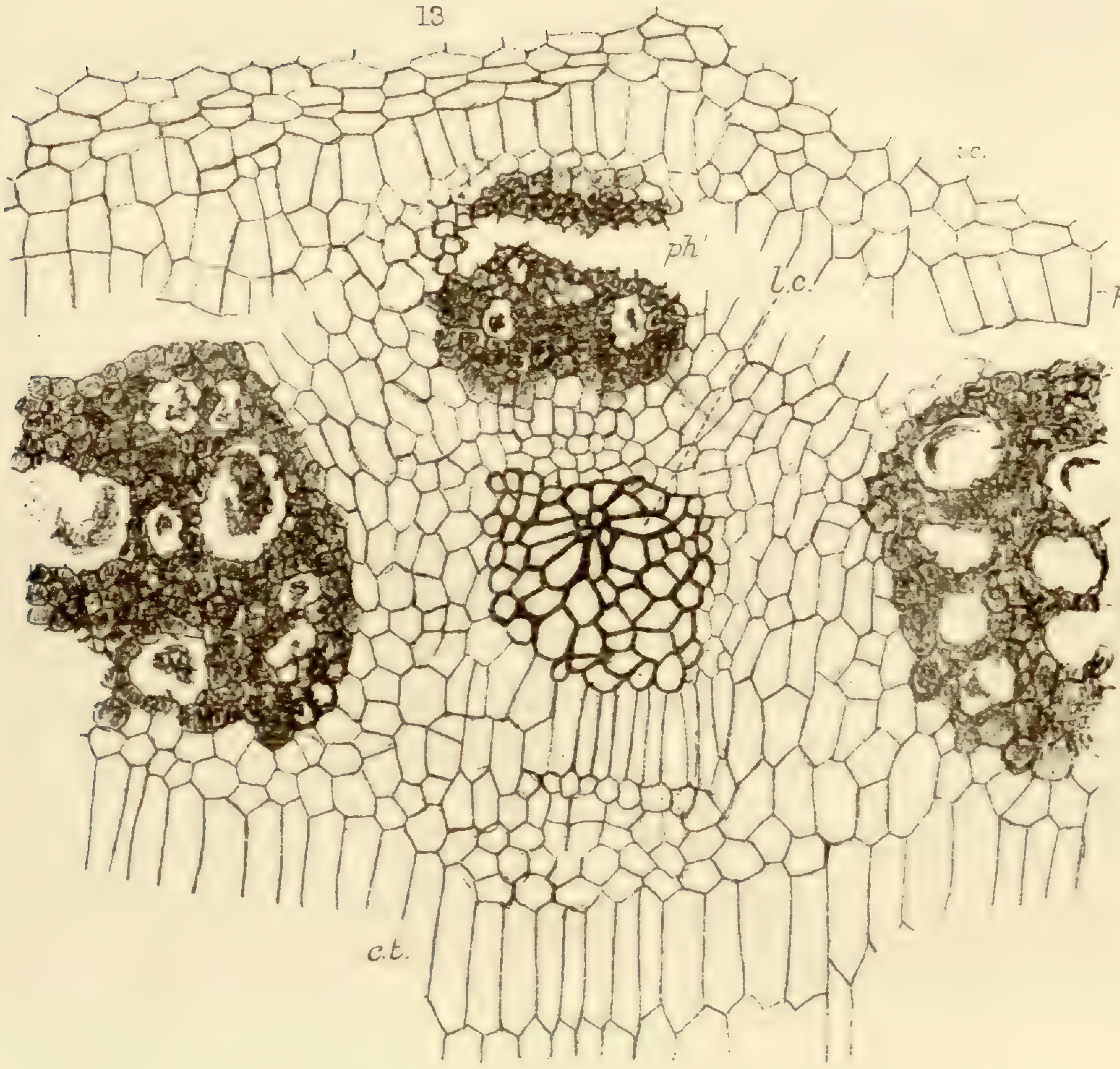
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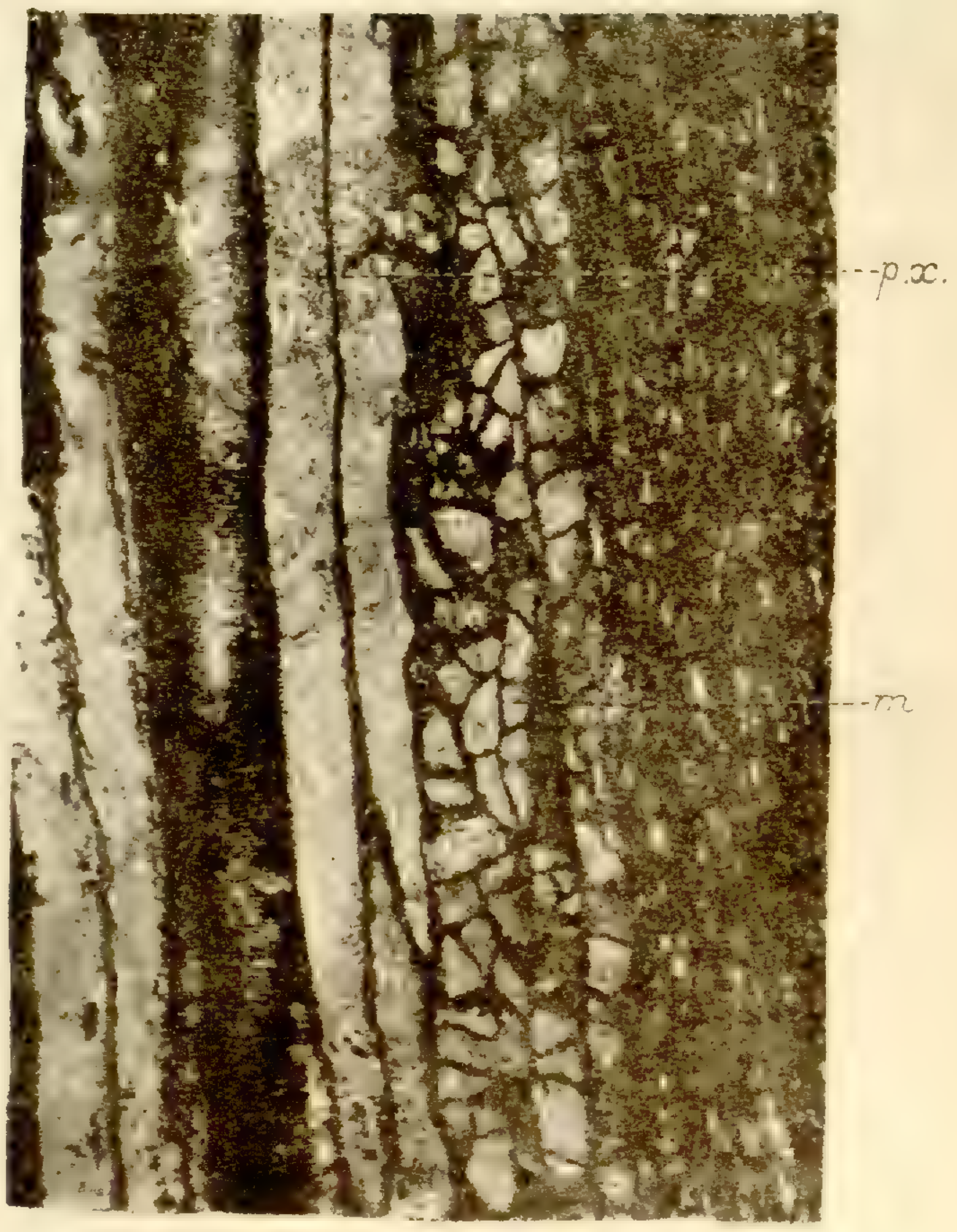

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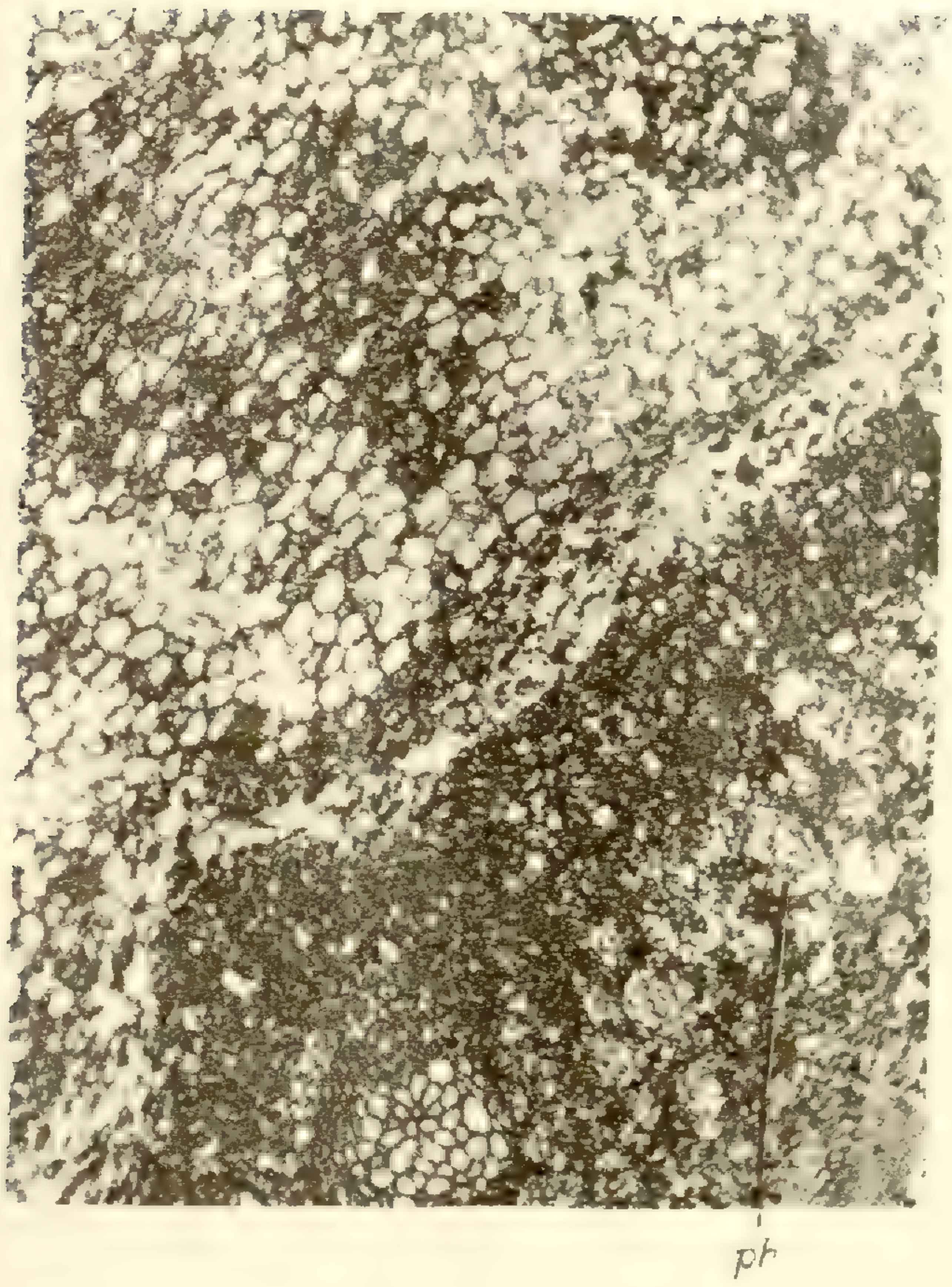

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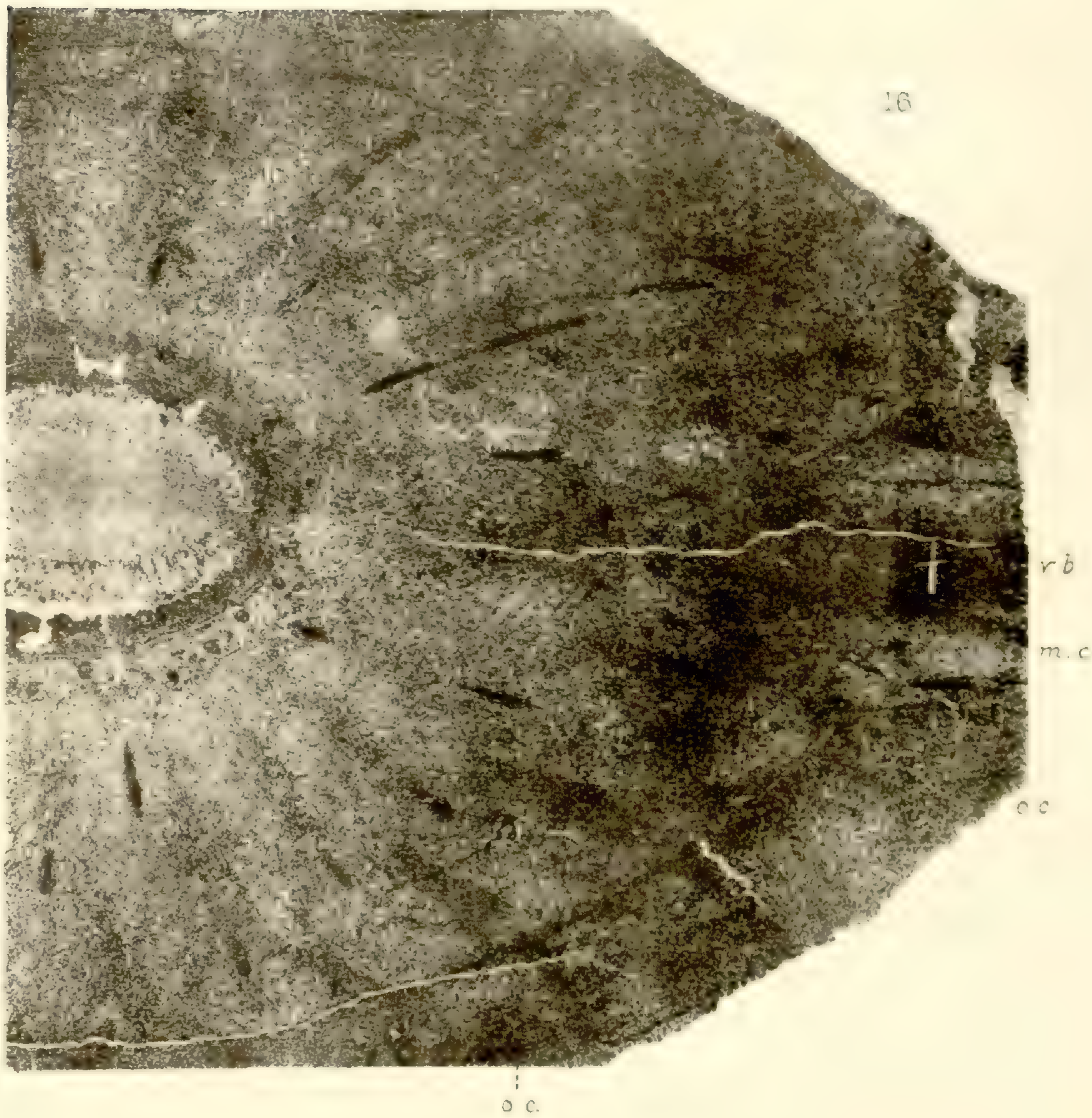

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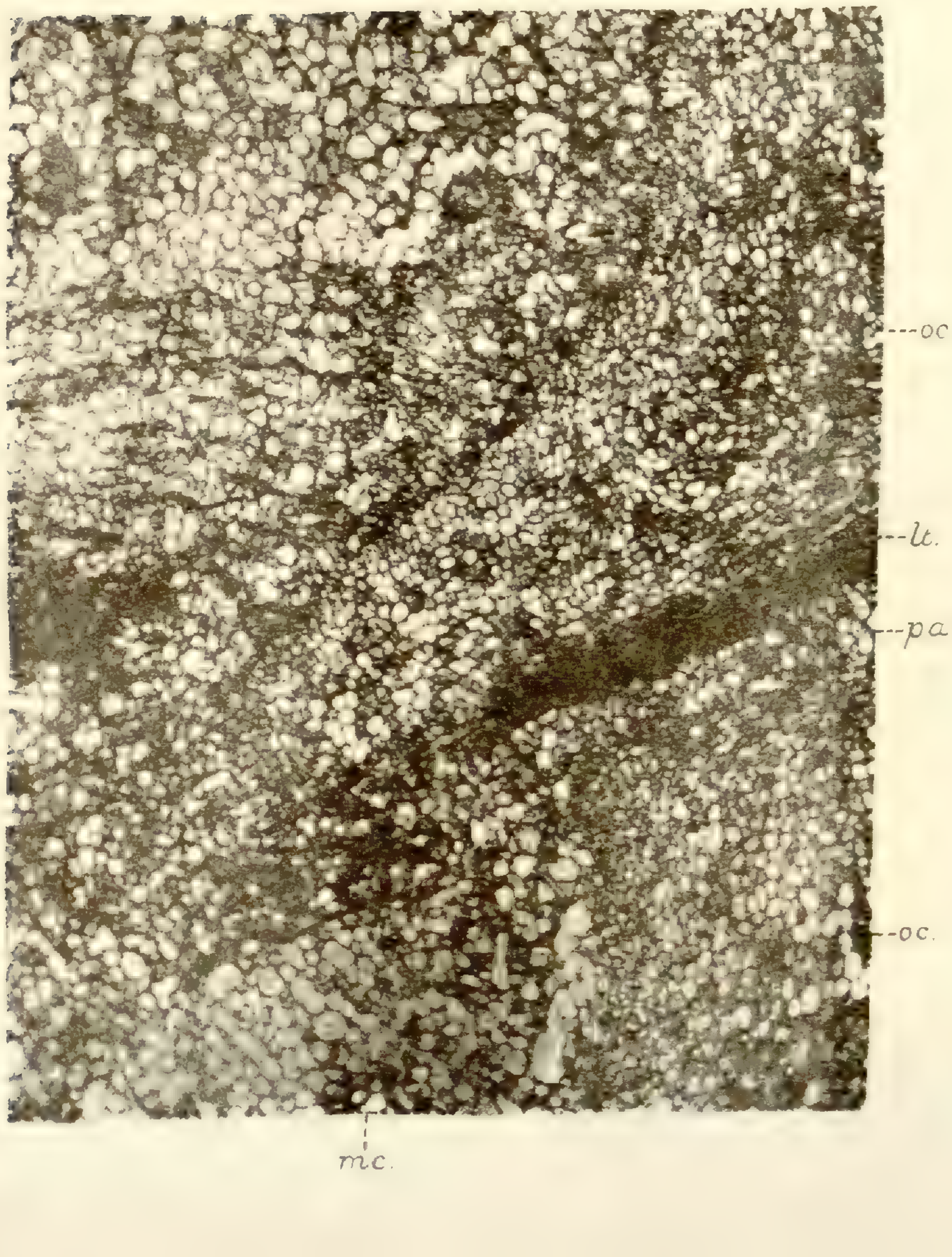
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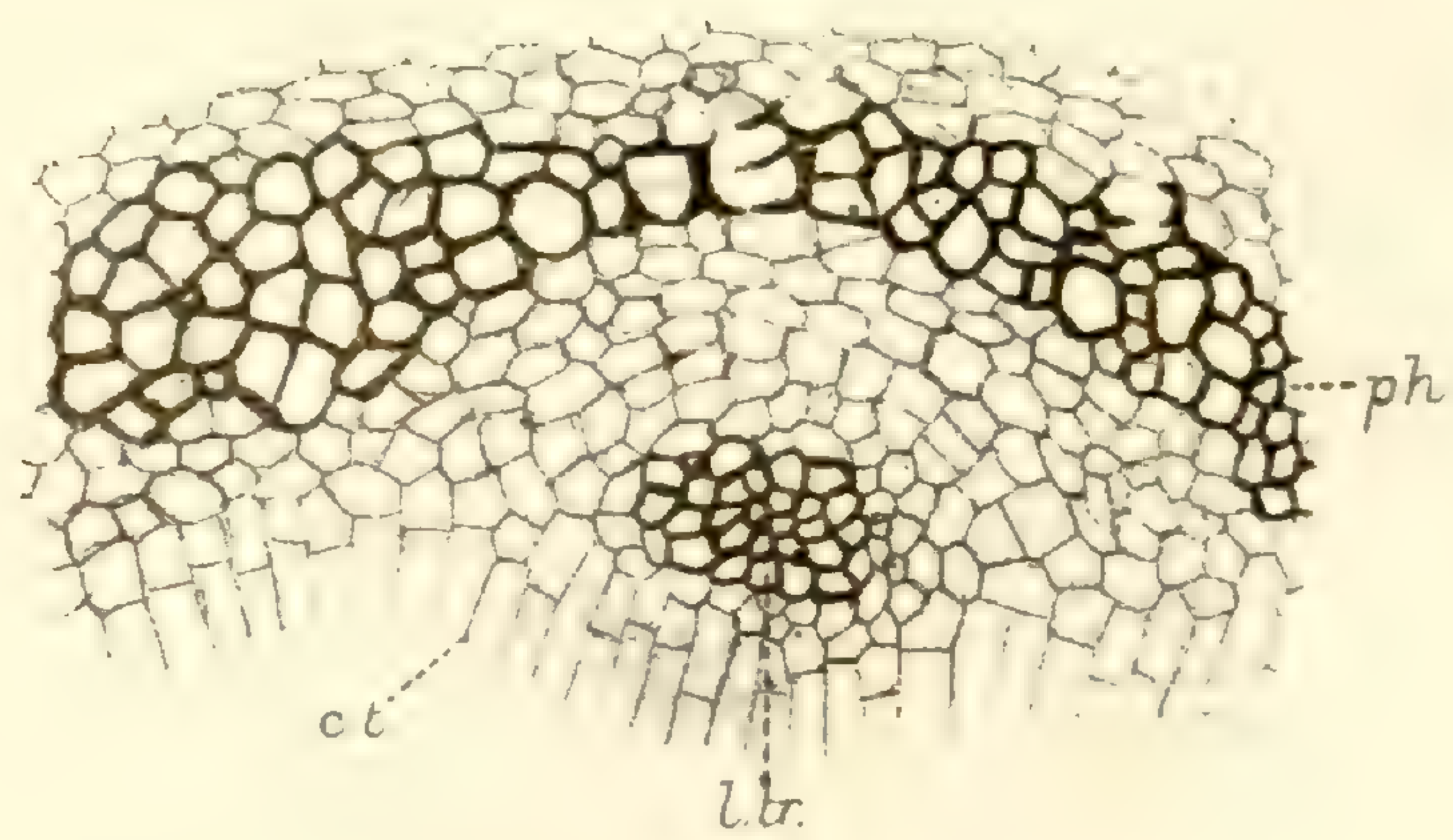

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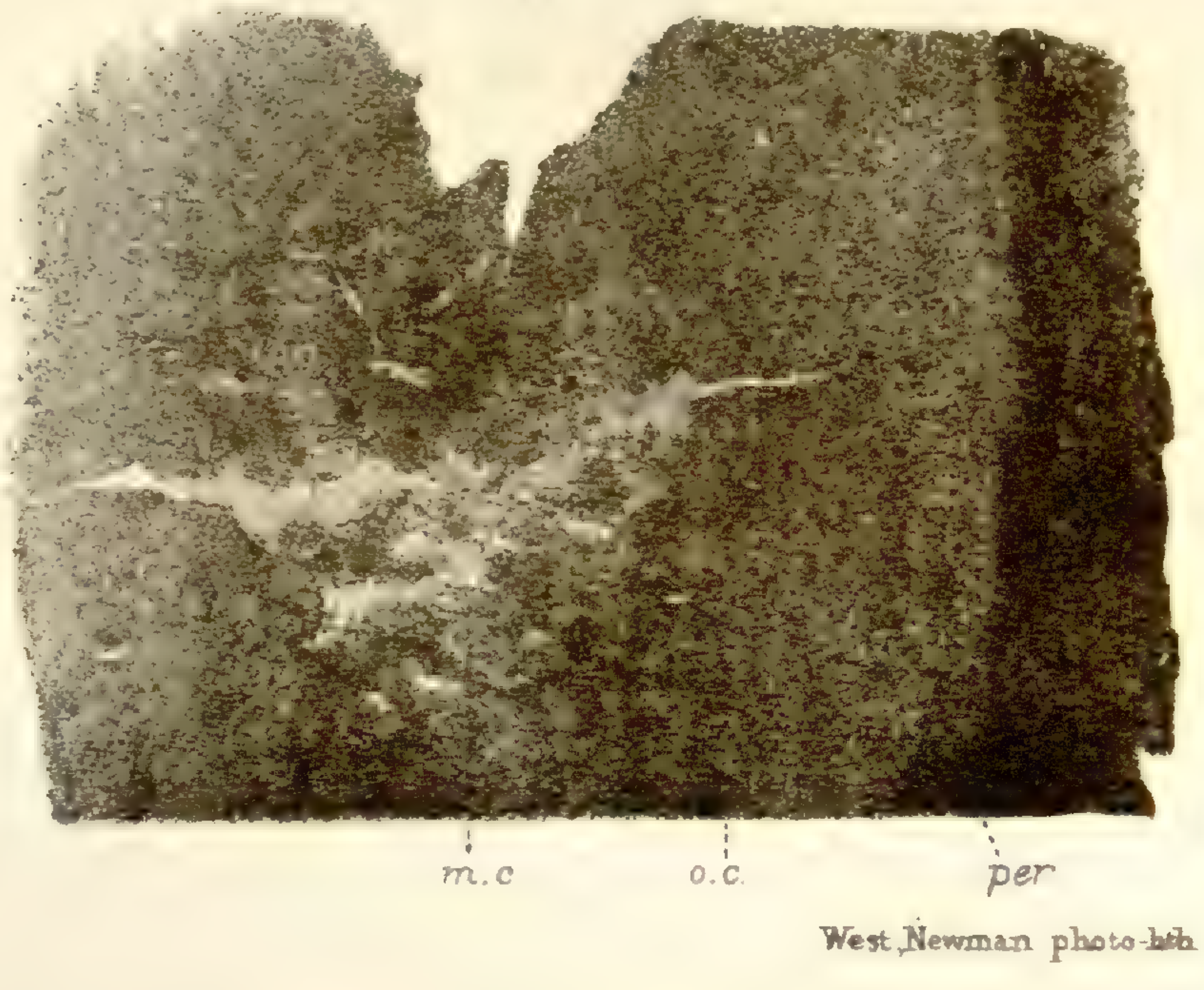

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THE

TRANSACTIONS

OF

THE LINNEAN SOCIETY OF LONDON.

THE ANATOMY OF TODEA, WITH NOTES ON THE GEOLOGICAL HISTORY AND AFFINITIES OF THE OSMUNDACEÆ

BY

A. C. SEWARD, F.R.S., F.L.S.,
UNIVERSITY LECTURER IN BOTANY,

AND

SIBILLE O. FORD,
BATHURST STUDENT, NEWNHAM COLLEGE, CAMBRIDGE.

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January 1903.

V. *The Anatomy of* Todea, *with Notes on the Geological History and Affinities of the Osmundaceæ.*

By A. C. Seward, *F.R.S., F.L.S., University Lecturer in Botany, and* Sibille O. Ford, *Bathurst Student, Newnham College, Cambridge.*

(Plates 27–30.)

Read 17th April, 1902.

Introduction.

THE Osmundaceæ have, on various grounds, been frequently referred to as occupying a somewhat isolated position among existing Ferns. Experience has shown that isolation is usually associated with a past history which reveals a greater vigour in former ages, as demonstrated by an abundance of fossil representatives widely distributed both in space and time. There are not a few surviving species of plants that remain as examples of blindly ending lines of evolutionary progress; or as relics of structural types, which have survived as evidence of a stage in phylogenetic development, from which have been evolved other styles of plant-architecture destined to assume a leading *rôle.* It is only from a few scattered and solitary examples that we obtain glimpses of pre-existing types or transitional styles, which enable us to trace to their origin the prevailing structural plans as illustrated by existing classes and families of plants. The former prominence of the Osmundaceæ in the vegetation of the world is demonstrated by an examination of Mesozoic floras from different regions. On the other hand, opinions differ as to the interpretation of the anatomical structure of the stem as an isolated type of plant-anatomy among existing Ferns. De Bary described *Osmunda* as affording an example, in the structure of its stem, of the occurrence of the "Dicotyledonous type" among the Filices [*]. Haberlandt [†] sees in the Osmundaceous central cylinder a transitional stage, which has persisted as an index of the course of events which marked the gradual evolution from a solid concentric stele (protostele) to the type of stele represented by Dicotyledons and Conifers. He interprets the continuity of the phloem-zone in *Osmunda* as a remnant of an earlier form of stelar structure in which the xylem also existed as a complete cylinder; in the course of evolution the woody portion of the vascular tissue became separated into distinct strands by outward radial extensions of a central pith, and a further encroachment of the medullary tissue caused a similar division of the phloem-zone, resulting in a ring of collateral bundles separated by medullary rays. Another interpretation of the Osmundaceous plan has recently been advanced by Jeffrey[*] and elaborated by Faull[†], which leads to the conclusion that "the cauline vegetative system of this family is neither primitive nor anomalous among the Filicales." This opinion is in striking contrast to that of Zenetti[‡], who speaks of the stelar structure of all other Ferns as "himmelweit verschieden" from that of the Osmundaceæ.

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[*] De Bary (1884), p. 280.

[†] Haberlandt (1896), p. 312.

With the exception of the description given by Faull of certain anatomical features of the stems of *Todea barbara* and the filmy species *T. superba*, our knowledge of the anatomy of the Osmundaceæ is almost confined to the genus *Osmunda*. The work embodied in the present paper was undertaken with a view of ascertaining how far the genus *Todea* agrees anatomically with *Osmunda*, and in order to obtain evidence which might throw light on certain peculiar histological features described by Zenetti in his excellent paper on *Osmunda regalis*. The opinion most widely held by botanists is that the Osmundaceæ are in many respects intermediate between the leptosporangiate Ferns and the Marattiaceæ. The occasional occurrence of synangia[§], the large and comparatively thick-walled sporangia[‖], the stipular wings of the leaf-stalk bases[¶], the nature of the apical meristems and certain characters of the gametophyte[**], constitute some of the grounds on which this view is based. We have confined our attention to the anatomy of the sporophyte of three species of *Todea*—*T. barbara*, Hook. f., *T. superba*, Col., and *T. hymenophylloides*, Rich. & Less.—and to a critical examination of the available palæobotanical data bearing on the past history of the family.

EXTERNAL FEATURES.

The genus *Todea* is represented by:—*T. barbara*, occurring in South Africa from the Cape to the Drakenberg Mountains, in Eastern Australia from Queensland to Tasmania, and in the North Island of New Zealand; *T.* (§ *Leptopteris*) *Wilkesiana*, a small tree-fern of the Fiji Islands, Samoa, the New Hebrides, and New Guinea; *T.* (§ *L.*) *superba*, a New Zealand species, characterized by a short erect stem; *T.* (§ *L.*) *hymenophylloides*, very similar to *T. superba*, and also confined to New Zealand; *T.* (§ *L.*) *Fraseri*, from New South Wales and New Caledonia; and some authors retain *T.* (§ *L.*) *Moorei* as a name of specific rank for a form confined to Lord Howe's Island.

In the 'Synopsis Filicum'[††] *Todea* is described as being represented by four species—*T. barbara*, placed in the section *Eutodea*; and three filmy species, *T. Fraseri*, *T. hymenophylloides*, and *T. superba*, included in the section *Leptopteris*. Presl proposed the name *Leptopteris* for the filmy species, which he considered should be generically separated from *Todea barbara*; but Milde in 1871[‡‡] showed that some of the characters on which Presl based his genus *Leptopteris* were of little value. Among recent writers Christ[§§] and Diels[‖‖] both retain *Leptopteris* as a distinct genus. The question of the union of both filmy and coriaceous forms in one genus or their separation as *Leptopteris* and *Todea* does not bear directly on the points with which we are chiefly concerned; but we prefer to follow Hooker and Baker in relegating Presl's genus to sectional rank, as this view appears to us to be more in accord with the close relationship that clearly exists between *Todea barbara* and the filmy species. Anatomical evidence is in support of the use of the name *Todea* in the wider sense.

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[*] Jeffrey (1901).

[†] Faull (1901).

[‡] Zenetti (1895).

[§] Bower (1899), p. 40, pl. 3. fig. 51.

[‖] Bower (1891), pl. 7. figs. 6–8.

[¶] Bower (1885).

[**] Kny (1872); Luerssen (1874); Campbell (1895) (1899); Heim (1896).

[††] Hooker & Baker (1868), p. 426.

[‡‡] Milde (1871).

[§§] Christ (1897), p. 332.

[‖‖] Diels (1900), p. 372.

TODEA.

Todea, Willdenow, 1802.

Todea barbara, Hook. f.

(Text-figs. 1 & 2. Pl. **27.** figs. 2, 3, 5; Pl. **28.** fig. 16; Pl. **29.** figs. 26, 27, 33, 34, 36, 38, 39, 40; Pl. **30.** figs. 42, 45, 50, 51, 52.)

1763. ***Acrostichum barbarum,*** Linnæus, Spec. Plant. vol. ii. p. 1529.
1837. ***Todea rivularis,*** Kunze, Anal. Pterid. p. 7, pl. 4.
1842. ***Todea africana,*** Hooker, 'Genera Filicum,' pl. 46 B.
1860. ***Todea africana,*** Hooker fil., Fl. Tasm. p. 153, pl. 168.
1872. ***Todea barbara,*** Hooker fil., Bot. Mag. vol. 28 (3). t. 5954.
1875. ***Todea barbara,*** J. Smith, Hist. Fil. pl. 27 *b*.

The stem of *Todea barbara* may reach considerable dimensions, forming a short and thick mass covered with a dense felt of brown roots, which completely hide the main bifurcated axis. One of the numerous plants of *T. barbara* sent to Europe by the late Sir Ferd. von Mueller has been figured, in which the stem reaches a breadth of 2·5 metres, a height of 1·76 m., and a thickness of 1 m. J. Smith [*] also described a specimen from the Victorian Alps of Australia measuring 5 ft. 8 in. in height, with a diameter of 7 ft. 9 in., and weighing 1 ton 3 cwt.; he adds that a plant was received at Kew in 1869 weighing 15 cwt. and bearing 30 crowns and 160 fronds. The stem of a *Todea barbara* in the Cambridge Botanic Garden measures 8 ft. in circumference and 3 ft. in height, with 14 distinct "crowns"; at the present time the crowns bear 230 fronds, with an average length of 7 ft. 6 in. The bipinnate fronds reach a length of 10 ft; the linear ultimate segments are occasionally more than 6 cm. in length and 6 mm. broad; the margin may be entire, but it is usually denticulate in the apical portion, the serrations occasionally extending the whole length of the segments. The fragment shown in Pl. **27.** fig. 5 was drawn from a specimen in the Kew Herbarium bearing the name "*Todea Vroomei*, a variety," from the Blue Mountains of New South Wales; this is clearly a form of *Todea barbara.*

The portions of pinnæ represented in Pl. **27.** figs. 2 & 3 also bear pinnules with slightly denticulate margins, more especially that shown in fig. 3, which is described in the Kew Herbarium sheet as "*T. barbara*, var." from New South Wales. The variation within the limits of the same species, as regards the degree of denticulation of the pinnules, is of interest in connection with the comparison of fossil forms.

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[*] Smith (1875).

The sporangia of *Todea barbara* are sometimes described as covering the under surface of the fertile segments without separation into definite sori. Several authors describe the sporangia as forming thick rows along the secondary veins, and assuming the form of single oval or forked sori *; the linear sori are, however, occasionally confluent and form a continuous mass of sporangia. A reference to many of the published figures of fertile pinnæ serves to illustrate the common occurrence of the sori, and the examples represented in Pl. **27.** figs. 2, 3, & 5 afford good instances of the grouping of the sporangia in well-defined and regular clusters. The sporangia of the Osmundaceæ may be described as comparatively large and spherical with a short and thick stalk; the annulus, of the usual leptosporangiate type, is replaced by a group of thicker-walled cells a short distance below the apex; the dehiscence is vertical. Bower † has pointed out that the sporangia of *T. barbara* contain more spores than those of the filmy species *T. superba* and *T. hymenophylloides*.

TODEA SUPERBA

(Pl. **28.** figs. 14, 18, 19, 21, 23; Pl. **29.** figs. 29, 30, 31, 32, 35; Pl. **30.** fig. 41)

and TODEA HYMENOPHYLLOIDES

(Pl. **28.** figs. 15, 17, 20, 24, 25; Pl. **29.** figs. 28, 37; Pl. **30.** figs. 43, 44, 46, 47, 48, 49).

1854. ***Todea superba,*** Hooker, Icon. Plant. vol. vi. (n. s.) t. 910.
1842. ***Todea hymenophylloides,*** Hooker, Gen. Fil. pl. 46 B.
1837. ***Todea pellucida,*** Hooker (= *T. hymenophylloides*), Icon. Plant. vol. i. t. 8.

The synonymy of the filmy species need not be given at length or discussed; there is a close agreement as regards the shape of the frond between the various forms described under different specific names. A comparison of the published figures of filmy Todeas and of Herbarium specimens convinces us that the form of the pinnules and the degree of dissection of the lamina are characters to which too much importance has been attached as diagnostic features.

References to illustrations of filmy forms are given in the footnote ‡. The most striking differences between *Todea barbara* and such species as *T. superba*, *T. hymenophylloides*, &c., are connected with the filmy § habit, as expressed in the much more slender lamina, the absence of stomata and intercellular spaces. The filmy species are characterized also by their smaller size; the sporangia on the fertile segments are less numerous, usually forming a small group confined to the basal part of the pinnule; but occasionally, as in specimens of *T. Fraseri* from the Blue Mountains, the sporangia almost cover the whole of the lower surface of the delicate lamina.

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* Christ (1897); Smith (1875); Hooker & Baker (1868); Prantl (1875), &c.

† Bower (1899), p. 38, &c.

‡ Hooker, Icon. Plant. 1831, pl. 101; *ibid.* 1837, pl. 8; *ibid.* 1854, pl. 910; Gardeners' Chronicle, 1870, p. 795, fig. 148; *ibid.* 1886, p. 752; L'Illust. Hort. vol. xxvii. 1870, pl. 38; *ibid.* 1876, pl. 270; Hooker, Gen. Fil. 1842, pl. 46; Field, Ferns of New Zealand, pls. 4 & 21 (1890).

§ See Boodle (1900), p. 484.

INTERNAL STRUCTURE.

A. *Seedling.*

The anatomy of the early stages in the development of the sporophyte of *Osmunda regalis* was described by Leclerc du Sablon in 1890 *, and Faull's recent paper in the 'Botanical Gazette' contains a brief description of the stele as seen in a transverse section of a young plant of *O. Claytoniana* †. Our examination of the seedlings ‡ (Pl. **27**. fig. 10) of *Todea hymenophylloides* shows that this species of *Todea* agrees in essential respects with *Osmunda regalis*. Near the apex of the primary root the stele includes two groups of xylem separated by a central group of unlignified elements (Pl. **28**. fig. 22); at a slightly higher level a single diarch plate is formed by the union of the two protoxylem strands (fig. 24). The next stage is shown in fig. 20 *a*; the centre of the stele is now occupied by a solid tracheal strand surrounded by thin-walled tissue, limited externally by an ill-defined endodermis. A protoxylem strand, indicating the position of a leaf-trace, is shown, as *px*, in a mesarch position. The endodermis is succeeded internally by a layer of parenchyma, the radial walls of which alternate with those of the endodermal layer, and this band of cells is separated from the nucleated parenchymatous elements by a layer of sieve-tubes. The whole is enclosed in a mass of sclerenchyma. At a higher level the stele is larger and the central tracheids have given place to a small island of parenchyma (Pl. **28**. fig. 25, *m*). The irregular endodermis is seen at *en*, succeeded by nucleated cells, *pr*, occupying the position of the pericycle; internal to these the sieve-tubes, *s*, are easily recognized, separated by parenchymatous elements, *xp*, from the scalariform tracheids; the smaller elements, *px*, probably indicate the position of the protoxylem of the leaf-trace, *lt*.

Plate **30**. fig. 48 shows a stele with a larger medullary region, *m*, and three outgoing leaf-traces; the endodermis is seen at *en*. The leaves are crowded in the young stem, and the passing out of a leaf-trace from the small medullated stele does not necessarily break the continuity of the xylem ring; in other words, leaf-gaps are not formed until we reach a slightly higher level. This is illustrated by fig. 20 *b*; the medullary parenchyma is larger than in the stele represented in fig. 25; a leaf-trace with its protoxylem, *px*, is on the point of freeing itself from the stele at *lt*, and at *lt′* another trace is beginning to bend out. At a higher level, fig. 20 *c*, the xylem band is broken and the overlapping foliar gaps produce an appearance characteristic of the older form of stele. We have not discovered any trace of an endodermal layer in the medullary region of the seedling stele. The stele of a young plant or "crown" borne on an old massive stem of *Todea barbara* is represented in Pl. **30**. fig. 52; the xylem exhibits the structure and arrangement of the mature stem on a small scale, and the pith consists of a homogeneous parenchyma without any indication of an internal endodermis in the perimedullary region.

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[*] Leclerc du Sablon (1890), p. 9.

[†] Faull (1901), p. 387, pl. 17. fig. 23.

[‡] We use this term, in spite of its inaccuracy, in preference to "sporeling."

B. *Apex of Main Stem* (*Todea barbara*, *T. hymenophylloides*, and *T. superba*).

A single three-sided cell terminating the apex of the stem has been observed in *Todea superba* (Pl. **28.** fig. 23) and *T. hymenophylloides.* In a section taken a short distance below the apex (Pl. **28.** fig. 18) numerous unlignified leaf-traces (*lt*) are shown clustered round the centre of the stem *c*, and in the peripheral region broadly triangular leaf-bases, with prominent lateral angles formed of the parenchymatous tissue of the basal wings *, occur in various stages of separation from the main axis. These leaf-bases present an appearance not unlike that of the fleshy leaf-cushions of a *Lepidodendron* twig. At a slightly lower level in the stem a fairly well-defined meristem-cylinder is recognized, succeeded internally by strands of large unlignified and nucleated xylem tracheids. The outer border of the deeply stained meristematic zone is formed by a somewhat irregular layer of cells of unequal size, the walls of which become suberized at an early stage (Pl. **28.** figs. 14, 15, 19, 21, *en*). This layer is the endodermis; we find no evidence in support of the view that it has a common origin with the broad band of tissue lying internal to it. The outermost xylem tracheids are succeeded by a zone of small cells (*xp*) which persist in the mature stem as a band of parenchyma. Beyond this zone a few large cells occur, which have lost their contents and are easily recognized, from their position and structure, as the first representatives of the large sieve-tubes of the mature stem (Pl. **28.** figs. 14, 15, 19, 21, *s*; *cf.* *s* in Pl. **28.** fig. 16; Pl. **29.** figs. 32, 33; Pl. **30.** figs. 42, 44, 46, 47).

The tissue between the sieve-tubes and the endodermis—the pericycle †—consists of several layers; the cells next the sieve-tubes are longer in a tangential direction and contain large nuclei (figs. 14, 15, &c., *t*), and these are undoubtedly the tangentially stretched elements of Zenetti ‡ ("quergestreckte Zellen") which Faull § describes as protophloem. These rectangular cells (*t*, Pl. **28.** figs. 14–17, 19, 21; Pl. **29.** figs. 26, 33, 39; Pl. **30.** fig. 42) pass gradually into rather shorter elements, while those abutting on the endodermis are characterized by still smaller dimensions (Pl. **28.** figs. 14, 19, 21).

A comparison of numerous sections of the stems of *Todea barbara* and the two filmy species (*cf.* Pl. **28.** figs. 14, 15, 16, 17, 19, 21; Pl. **29.** figs. 32, 33; Pl. **30.** figs. 42, &c.) leads us to the conclusion that the large clear sieve-tubes in the stem are the oldest phloem elements—the protophloem; and the tangentially elongated elements, which at a later stage in the growth of the stem assume the characters of sieve-tubes (Pl. **28.** fig. 16, *t*), are of later origin. This order of development suggests a comparison with the centrifugal differentiation of the phloem described in *Angiopteris* ‖. Fig. 29, Pl. 29, represents a diagrammatic drawing of the transverse section of the young stele of *Todea superba*, part of which is shown on a larger scale in fig. 19. The dark dots (*px*) mark the position of the protoxylem elements, which in this section always occupy a mesarch position close to the outer edge of the tracheal strands. The mesarch character is particularly striking and in marked contrast to the more usual endarch xylem of *Osmunda regalis* and *Todea barbara*. The conspicuous sieve-tubes are represented by dots, *s*; and the line *en* marks the position of the endodermis. The abundance of sieve-tubes opposite the medullary rays, and external to the concavities on the outer face of the xylem groups, is a constant feature in all the species examined. This diagram also illustrates stages in the separation of leaf-traces and roots (*lt* and *r*) from the xylem of the central cylinder. A portion of this section is shown in fig. 21; a lignified protoxylem island is seen near the outer edge of the large unlignified tracheids; beyond the zone of parenchyma, *xp*, a band of comparatively large and fully developed sieve-tubes stands out clearly; the sieve-tubes contain numerous highly refractive granules, and agree in every respect with those of the mature stem. The tangentially elongated cells, *t*, still retain their large nuclei. A similar structure is shown in fig. 15, which represents part of a transverse section from the apical region of *Todea hymenophylloides*; the protoxylem elements are almost exarch in position; the parenchymatous band, *xp*, is followed by a layer of sieve-tubes, *s*, and beyond these are a few layers of long rectangular cells, *pr*. The endodermis, *en*, is rather more distinct in this species than in *T. barbara* or *T. superba*, and is characterized by the suberization of the cell-walls occasionally extending beyond the limits of a single layer.

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* For an account of the "wings," see Bower (1885), pl. 37, &c.

† The term "pericycle" may be conveniently used, as suggested by Mr. Boodle, without the implication of a definite morphological significance; Boodle (1900), p. 459.

‡ Zenetti (1895).

§ Faull (1901).

‖ Shove (1900). Miss Shove's results as to the internal position of the protophloem have recently been confirmed and extended by Mr. Brebner (1901).

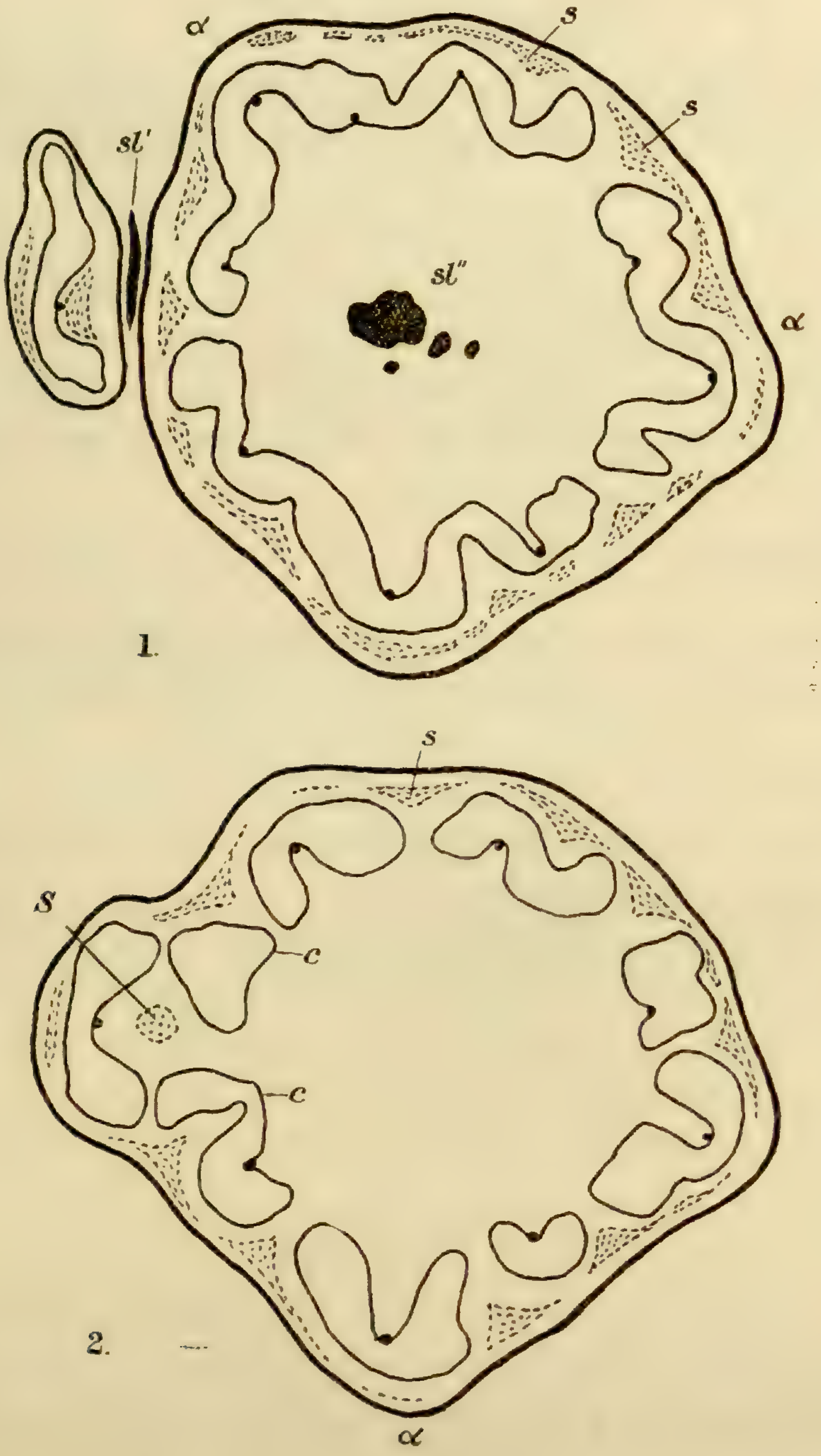
The more important points which we believe to be demonstrated by the sections from the apical portion of *Todea* stems are:—(i) The tangentially elongated elements do not represent protophloem, but are of later origin than the large sieve-tubes of the mature stem; (ii) the endodermis is not of common origin with the tissues lying internal to it.

In the tissue between the endodermis and the sieve-tubes (*pr*, figs. 14, 15, &c.) there is no satisfactory evidence of any distinct line of division separating an outer (pericycle) region from an internal undifferentiated phloem portion. At a later stage of growth the more internal elements of the zone of cells between the endodermis and the sieve-tubes appear as thick-walled elements having their larger axis in a horizontal plane and with their tangential walls separated by reticulate thickening bands into numerous sieve-areas (Pl. **28**. fig. 16, *t*). Traces of similar bands are occasionally faintly indicated on the walls of the more external cells, and even in the mature stem any division of this zone into pericycle and external phloem would be purely arbitrary and artificial.

C. *Mature Stem.*

TODEA BARBARA.—A transverse section of a mature stem of *Todea barbara* presents an appearance very similar to that of *Osmunda regalis*. The stele, which in the plant investigated had a diameter of 5 mm., stands out as a clearly marked pentagonal area (Pl. **29**. fig. 26; text-figs. 1 & 2) limited by an endodermal layer; a band of thin-walled parenchyma separates the central cylinder from the peripheral region of the stem, which consists of a mass of dark brown sclerenchyma enclosing numerous islands formed of outgoing leaves and curving roots cut across in various directions. In the more internal region of the cortex the mechanical tissue occurs as crescent-shaped patches on the concave face of the leaf-traces (text-fig. 1, *sl'*), but these soon become merged into a common dark brown mass formed of the confluent sclerenchymatous envelopes of petioles and roots. The patch of sclerous tissue lying in the angle made by an outgoing leaf-trace with the main stele (text-fig. 1, *sl'*), from which it passes up in an obliquely ascending direction, is characterized by the unusual thickness of the walls and the almost complete obliteration of the cell-lumen; this increased strength of the supporting tissue in the axil of a lateral member where a break might easily occur is a common phenomenon among plants. The xylem of the stele forms a sinuous band made up of not more than 7–8 and not less than 2 tracheal strands separated by medullary rays 3–4 cells in breadth (text-figs. 1 & 2). The greater continuity of the xylem and the smaller number of medullary rays form one of the characteristic features of this stem as compared with that of *Osmunda*, in which the medullary rays are more numerous. In shape the xylem strands vary from oval or horseshoe-shaped groups to continuous

Text-figs. 1 & 2.



undulatory bands stretching a considerable distance round the pith, as seen in transverse section. The tracheal strands consist almost entirely of scalariform tracheids, with here and there an included parenchymatous cell; in the strands with mesarch protoxylem groups a few parenchymatous elements often accompany the spiral tracheids. An occasional tracheid is rarely met with detached from the xylem strands and lying in a medullary ray. A few short reticulately thickened tracheids are sometimes found on the inner edge of the xylem, as described in some stems of *Lepidodendron*. The distribution of the narrow protoxylem elements is shown in Pl. **29.** figs. 26, 27, *px*, and in text-figs. 1 & 2 by the dark dots; these usually occupy an endarch position (*e. g.* Pl. **30.** fig. 42, *px*), but some of the xylem groups have a mesarch structure (fig. 26). The smaller strands in the xylem ring are occasionally without any protoxylem elements (fig. 36 & text-fig. 2), and in the more continuous sinuous bands the protoxylem tracheids may be separated by long intervals. The pith consists of parenchymatous tissue in the centre of which an irregular group of dark brown sclerous elements occasionally occurs: this is more particularly the case in the older parts of the stem. These medullary nests of sclerous cells (text-fig. 1, *sl''*) in *Todea barbara* are not accompanied by an encircling endodermal layer, nor have we detected any trace of an internal endodermis in this species. The xylem ring is surrounded externally by a band of parenchyma (figs. 16, 26, 33, *xp*) which varies in breadth in different regions, and is clearly distinguished by the deeply stained cell-contents from the more external phloem-zone. The phloem consists internally of large sieve-tubes forming a band of varying thickness, which projects as triangular groups into the outer end of the medullary rays (text-figs. 1 & 2; Pl. **28.** fig. 16, *s*; Pl. **29.** figs. 26, 33, *s*; Pl. **30.** fig. 42, *s*). The sieve-tubes of *Todea* agree with those of *Osmunda* * in the possession of numerous sieve-areas on their radial walls. Here and there the sieve-tube band is interrupted (fig. 26, and text-figs. 1 & 2), but the phloem as a whole constitutes a continuous zone, the continuity being maintained by the more horizontally placed sieve-tube elements (*t*, fig. 26, &c.) which have been referred to in the description of the apical region. The structure of the extra-xylem tissue is shown in figs. 16, 33, & 42. The large vertical sieve-tubes, *s*, are succeeded by the more horizontal or tangentially elongated elements with comparatively thick walls divided by reticulate thickenings into numerous sieve-areas (*t*, figs. 26, 33, 40). This band of tangentially disposed sieve-tubes is separated from the endodermis by a zone composed of from 4–5 layers of cells (*pr*, figs. 33 & 42), which pass by gradual stages into the horizontal sieve-tubes, *t*, and are clearly derived from the same meristematic band. The tangentially elongated sieve-tubes pursue a more vertical course opposite the xylem which is about to bend outwards as a leaf-trace †.

As shown in figs. 16 & 33, the cells of this zone, especially those of the layer next the horizontal sieve-tubes, *t*, show traces of thickening bands on their walls; these appear to represent in a feebly developed condition the more obvious reticulations of the tangentially elongated elements, *t*. The endodermis, *en*, usually consists of a single row of cells of unequal size, and is not always very clearly defined (fig. 16, Pl. **28**; fig. 33, Pl. **29**; fig. 42, Pl. **30**).

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* *Cf.* Zenetti (1895); Janczewski (1880).

† *Cf.* Faull (1901), p. 404.

D. *Leaf-traces and the Course of the Protoxylem Strands.*

The phyllotaxis of *Todea barbara* appears to be represented by the fraction $\frac{8}{21}$. In any transverse section of the stem, one or more xylem groups situated at the rounded angles of the polygonal stele are seen to be bending outwards (Pl. **29.** fig. 26, α; text-figs. 1 & 2, α) preparatory to cutting off their outer portions as the single curved band of vascular tissue which passes into each leaf. A single group of protoxylem occurs on the concave side of these tracheal strands, and in one or two cases two groups of spiral elements were noticed. After the arch of a horseshoe-shaped band has been detached, the two ends of the arms, or compensating strands (Pl. **29.** fig. 38, *c*), remain in the stele of the stem. It is difficult to follow the course of the compensating strands in *Todea* owing to the small degree of separation between the xylem groups of the stem. The course of the xylem strands is illustrated by the diagram shown in fig. 27, Pl. **29.** Beginning with the lowest leaf-trace *n*, it is seen that the left-hand compensating strand soon unites with its left-hand neighbour and the joint strand gives off a leaf-trace, $n+3$, at a higher level. Similarly the left-hand strand of $n+1$ unites with the adjacent xylem group—the right-hand strand of leaf-trace *n*—and the common strand gives rise to leaf-trace $n+4$. The right-hand compensating strand left in the stem after the exit of a leaf-trace continues as a single strand for a short distance, and then unites with its neighbour on the right. The joint bundle gives off a leaf-trace 4–5 internodes higher up the stem.

Zenetti has given an interesting account of the origin of the leaf-traces in *Osmunda regalis*, which in essentials might be extended to *Todea*. As a xylem strand arches outwards and becomes elongated in a radial direction (text-figs. 1 & 2, α), a few tracheids begin to bend out from the shoulders of the depressed arch to form the steles of the two roots that are in close connection with each leaf-trace. The roots do not usually arise at precisely the same level; they may appear as at *r*, *r* in fig. 38, Pl. **29**, or, as more frequently happens, one may appear before the other (fig. 39, *r*). In some instances the steles of the roots are not given off until the leaf-trace has passed into the extra-stelar tissue, but as a rule one at least may be detected before the foliar bundle has left the stele. The tangentially elongated sieve-tubes are replaced by narrower and more vertically placed sieve-tubes in the region immediately external to an outgoing leaf-trace. The crest of the arched xylem band is gradually detached from the lower ends of the two limbs, which remain behind as the compensating strands (text-fig. 2, *c*, *c*; also fig. 38, Pl. **29**): these may be small oval strands, one of which only contains a mesarch protoxylem group (fig. 38, *c*, *c*), or one or both of the compensating strands may be in direct continuity with a sinuous xylem band (fig. 39, Pl. **29**; text-fig. 2). At about the stage when separation of the trace occurs, a conspicuous group of sieve-tubes appears on the concave side of the foliar strand (text-fig. 2, *s*; figs. 38, 39, *s'*). Zenetti* has described how this apparent island of phloem is in reality the lower end of a strand of the stelar phloem from a higher level, which bends upwards in the form of a **U**-shaped loop to constitute the inner phloem of the concentric leaf-trace. This author gives a figure illustrating the curious bending of the sieve-tubes as they pass down into the space between the trace and the medullary ray immediately behind it and curve round and pursue an obliquely vertical upward course. Fig. 34, Pl. 29, represents a diagrammatic view of a longitudinal section cut along the plane shown by the line *ab* in fig. 38. The parenchymatous tissue on the right belongs to the medullary ray, *mr*; the sieve-tubes, *s'*, bend round in a loop and extend upwards at *s''* on the inner face of the xylem of the leaf-trace, *lt*. Two of the sieve-tubes of the group *s'* of fig. 39 are drawn on a larger scale in Pl. 29. fig. 40. The photograph reproduced in fig. 50 shows the xylem elements bending round (as seen in a section cut in the direction indicated by *cd* in fig. 38, but at rather a higher level where the leaf-trace has passed a little farther out) from the stem of the leaf. The sclerous group that makes its appearance between the leaf-trace of the stem (text-fig. 1, *sl'*) is represented in fig. 50 by a single thick-walled element *sl*. The dark line *pp* represents rather crushed and thick phloem elements, and at *rt* the root-tracheids are seen passing out at right angles to the trace. The protoxylem groups met with at any level of the stem are downward continuations of the protoxylem of the leaf-traces, but each protoxylem strand when followed in a downward direction is found to gradually decrease in size until it disappears. The strand of xylem in which a group of protoxylem disappears bears a constant relation to the leaf-trace in which the spiral elements originated; it is the left-hand compensating strand of the eighth leaf-trace lower down the stem. The protoxylem group entering from leaf-trace $n+11$ ends in the left-hand strand of leaf-trace $n+3$; those from leaf-traces $n+10$, $n+9$, and $n+8$ terminate in the left-hand strands of $n+2$, $n+1$, and n respectively (Pl. 29. fig. 27, *px*). The single protoxylem group of a leaf-trace gradually becomes broader as the foliar stele passes outwards, and by repeated branching gives rise to the numerous endarch protoxylem groups which occur in the petiole.

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* Zenetti (1895), pl. 2. fig. 11.

E. *Leaf and Root.*

There is little to record in regard to the structure of the leaf. The broad U-shaped stele consists of a narrow metaxylem band, 1–2 tracheids in width, with several endarch protoxylem groups; this is encircled by the phloem, of which the sieve-tubes are smaller than those in the stele of the stem. The phloem on the convex side of the xylem is broader than that on the concave side. Groups of mucilage-sacs (Pl. 30. fig. 45) occur on the concave side of the xylem in the pericycle region, and the parenchymatous tissue abutting on the protoxylem strands occasionally forms small irregular cavities (Pl. 29. fig. 36, *sp*) (cavity-parenchyma). The mesophyll of the lamina consists of loosely arranged cells of irregular shape; but in the filmy species, *e. g.* *T. hymenophylloides*, the lamina is composed of a central layer of one or two large cells in width between the upper and lower epidermis, of which the cells have papillose outer walls and contain numerous chloroplasts.

A well-known feature of the leaf of the Osmundaceæ is the prominence of the lateral wings at the base of the leaf-stalk *. These basal expansions or "stipules" consist of parenchymatous tissue traversed by obliquely running sclerenchymatous strands. The prominent wings of young petioles have been referred to in the account of the apex of the stem. The parenchymatous tissue of the stipules is prolonged upwards as three or more layers of green tissue covering the lower part of the leaf-stalk. We have not noticed any of the slits between the epidermal cells of the petioles mentioned by Thomae*.

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* Bower (1885).

A characteristic feature of the young fronds of the Osmundaceæ is the presence of numerous filamentous hairs in place of the scaly ramenta of most Ferns. In a circinately coiled frond of *Todea barbara*, shown in Pl. 30. fig 51, a mass of these hairs is seen at *h*; they consist of long and frequently branched filaments which arise from epidermal cells on the inner face of the young leaf.

In a transverse section of the petiole, shown in fig. 51, taken at the level *a*, the stele was found to contain 26 protoxylem groups alternating with as many islands of large mucilage-sacs; at this level lignification was confined to the small protoxylem tracheids, and, as shown in fig. 36, Pl. 29, a large space containing remnants of spiral bands (*sp*) had already been formed and appeared as a more prominent cavity than in the older part of the petiole (*cf.* fig. 45, *px*).

The most external elements of the phloem on the convex side of the leaf-stele exhibit the usual characteristics of protophloem, and in sections cut from the level *a* of the young frond (Pl. 30. fig. 51) they are already differentiated as small clear sieve-tubes. These protophloem elements (*pp*, fig. 50) may be traced downwards into continuity with the tangentially-placed sieve-tubes in the phloem of the stem. We have already expressed our belief that the thicker-walled and horizontal sieve-tubes in the stem (fig. 42, *t*, &c.) are not true protophloem. In other words, the first-formed phloem elements in the apical region of the stem are not continuous with the protophloem of the leaf.

It is unnecessary to describe the structure of the roots; they are usually diarch or triarch, and in a few instances a tetrarch stele was met with.

TODEA SUPERBA.—The stem of this species agrees in the general plan of the stele with *T. barbara*, but differs in detail. In the plant examined the stele had a diameter of 2·2 mm., being therefore much smaller than that of *T. barbara*. The xylem is characterized by its greater continuity; it sometimes forms a completed sinuous ring (Pl. 30. fig. 41), or it may be interrupted by a single medullary ray occasionally one cell in breadth. In the section represented in Pl. 29. fig. 29 there are seven xylem strands.

A few tracheids of exceptional breadth were found here and there in the xylem strands; some of these, four or five times broader than the usual type, are represented at *x*, Pl. 29. figs. 30 & 31; the large diameter and short length suggest a storage rather than a conducting function. The position of these large tracheids is shown at *a* in fig. 29; they occur sporadically in the stem and are not confined to any particular region. These large tracheal elements may be compared with the short and wide tracheids of the metaxylem of *Megaloxylon*[*]. The tangential elongation of the elements external to the larger sieve-tubes is less marked than in *T. barbara*. The endodermis forms a more clearly defined layer, and its position is often clearly shown by the readiness with which its cell-walls are broken in the process of section-cutting (fig. 32, *en*). The structure of the apical region of the stem of *Todea superba* has already been described (figs. 14, 19, & 21), and reference has been made to the more pronounced mesarch character of the xylem groups. The manner of exit of the leaf-traces (figs. 29, 35) is similar to that described in *T. barbara*. In the diagram shown in fig. 35 the broad band of sieve-tubes, *s*, represents the phloem of the stem which bends up as a loop to give off a branch to the outgoing leaf-trace (shown at a later stage in *Todea barbara* in Pl. 29. fig. 39, *s′*). The roots are frequently given off from the xylem before it has left the stele of the stem, and the two formed in connection with each leaf-trace do not arise at the same level (fig. 29, Pl. 29, *r*).

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* Thomae (1886).

The dark band (β) shown in fig. 32 is due to a brown deposit in the region of the tangentially elongated elements as seen in a section taken from the basal region of the stem, where the tissues showed signs of decay.

Todea hymenophylloides.—One plant of this species was examined in which the stele could be traced for a distance of about 2 cm. In its widest part the stele had a diameter of nearly 3 mm. The xylem is characterized by the greater number of the strands (Pl. **30**. fig. 44) as compared with *T. superba*; there may be as many as ten or eleven in the upper region of the stem, but towards the base the number gradually decreases until the xylem eventually appears as a ring enclosing a central pith (fig. 37, Pl. **29**). The form of the xylem near the base of the stem, shown in fig. 37, is practically identical with that of the seedling stele represented in fig. 48; in neither case is there any indication of an internal endodermis. As shown in Pl. **30**. figs. 44, 46, 47, and 49, the xylem strands appear either as oval groups, with or without protoxylem elements (fig. 46), or as U-shaped groups which are about to give off the outer portion as a leaf-trace. The protoxylem is always mesarch, and nearer the outer edge of the xylem group than in the other species examined; this near approach to the exarch structure is clearly shown in fig. 47. A few unusually large tracheids, similar to those in *T. superba* (figs. 30 & 31), were met with in the xylem strands of *T. hymenophylloides*. The large clear sieve-tubes form groups in the outer part of the medullary rays (*s*, figs. 17, 44, 46, 47), and agree closely in arrangement with the sieve-tubes of the other species. The tangentially elongated elements (Pl. **28**. fig. 17, *t*) are very similar to those in *T. superba*. The endodermis is clearly marked, but the suberization is not always confined to one cell-layer (Pl. **28**. figs. 15 & 17, *en*). *Todea hymenophylloides* is characterized by having an internal endodermis; this occurs as an irregular layer of cells with suberized walls (Pl. **29**. fig. 28, *en′*; Pl. **30**. fig. 44, *en′*). It is noteworthy that this inner endodermis does not form a very compact or well-marked layer; it was found in a few sections near the apex of the stem, and here and there in the peripheral region of the pith in the lower part of the stele, but it is by no means continuous. The suberization is not confined to one layer, and the cells are larger and wider than those of the better marked outer endodermis.

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[*] Seward (1897).

The leaf-traces (figs. 44, 46, 47, 49, Pl. 30) are given off as in the other species, and, as in *T. superba*, the roots do not arise at the same level, nor do they appear always at the same stage on the outgoing leaf-trace. In the photograph reproduced in Pl. 30. fig. 46, the endodermis of the stele is seen to be bent round the leaf-trace *lt*, and is about to separate itself from that of the foliar bundle. Another feature worth noting is the greater difference in the diameter of the outer tracheids of the stem as compared with the more internal xylem elements (figs. 44, 46, 49, Pl. 30): this is seen also in *T. superba* (Pl. 30. fig. 41), but is less marked in *T. barbara*.

Geological History.

As a result of the more minute investigation of Palæozoic plants carried out during the last few decades, facts have been gradually accumulating which enable us to recognize in the morphological features of many extinct species signs of union in the remote past of types of vegetation that are now clearly distinguished one from another. The numerous types of fern sori and sporangia, and the various anatomical features exhibited by the structure of the vegetative organs of Ferns and Fern-allies, afford striking illustrations of the importance of Palæozoic Botany as a guide to phylogeny. Existing Ferns are in the main divided into fairly well-defined families characterized by clearly marked features; but among Palæozoic representatives of the Filicales and Cycadofilices we find, instead of the separate lines of affinity exemplified by living forms, an intricate plexus of branches which are not amenable to the same kind of classificatory treatment as the modern Ferns. While the majority of the sporangia found on fertile pinnæ of Palæozoic fronds agree more closely with those of the recent Marattiaceæ than with the Leptosporangiate ferns, there are several instances of the admixture with the Marattiaceous features of others suggestive of a closer union between fern families than exists at the present day. The Botryopterideæ represent a family of Palæozoic Ferns which cannot be accommodated in any existing division; they afford links on the one hand with members of the Osmundaceæ, and on the other hand with certain species of Hymenophyllaceæ. The sporangia of *Botryopteris* have been described by Renault *, and more recently by Scott †; as the latter author points out, the characteristic and prominent annulus may be compared with the so-called annulus of *Osmunda* or *Todea* in an exaggerated form. A recently discovered type, described by Zeiller ‡ from Asia Minor as *Kidstonia*, possesses sporangia with a prominent group of cells forming a cap-like annulus (Pl. 27. figs. 6 & 9), intermediate in structure between the apical annulus of the Schizæaceæ and the intra-apical group in the Osmundaceæ.

From the Culm of Esnost, Renault has recorded pyriform and short-stalked sporangia under the name *Todeopsis primæva* §, characterized by the possession of a group of large cells not unlike the brown and thicker-walled cells of the subapical "annulus" of an Osmundaceous sporangium. Some of the sporangia described by Williamson and others from the calcareous nodules of English coal-seams have been shown by Bower * to bear a close resemblance to those of *Todea*; and Zeiller † has figured examples of sporangia found by Renault in quartz pebbles from Autun which recall those of recent Osmundaceæ. Zeiller has also given an account of another type of sporangium borne on *Sphenopteris*-fronds from the Palæozoic plant-beds of Zongouldak in Asia Minor, which he refers to Stur's genus *Discopteris*. One of these sporangia (*D. Rallii*) is shown in Pl. 27. fig. 12; the narrow cells running along the upper face mark the line along which dehiscence takes place. The sporangia are without an annulus, but large polygonal cells with slightly thickened walls occur on the dorsal face, and similar cells are shown at the distal end of the figured example. This occurrence of rather thick-walled cells led Stur to describe sporangia of the *Discopteris* type ‡, which he placed in the Marattiaceæ, as having a rudimentary apical annulus. Zeiller § interprets the structure of the wall as being intermediate in character between that of a sporangium in which there is no differentiation, and one which is characterized by a well-defined group of thick-walled cells such as occurs in the Osmundaceæ.

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* Renault (1896), pp. 33 *et seq.*

† See Scott (1890), pp. 297 *et seq.*

‡ Zeiller (1899), p. 22.

§ Renault (1896), p. 21, fig. 18.

Among the Cycadofilices, interesting examples are recorded of anatomical features recalling those of the recent Osmundaceæ. "The nearest analogy to *Lyginodendron* among recent Ferns is probably to be found in *Osmunda* . . . . The leaf-trace bundles, however, unlike those of *Lyginodendron*, become concentric immediately on leaving the stele." Another difference from the fossil genus is that in *Osmunda* the phloem forms a continuous ring, which does not seem to have been the case with the primary phloem of *Lyginodendron*. The position of the protoxylem is also different. In *Lyginodendron*, as we have seen, all bundles are mesarch, with the protoxylem strands embedded in the primary wood nearer its outer than its inner surface. In *Osmunda* the bundles only have protoxylem at all in the upper part of their course. In the bundles, where they first enter the stele, the protoxylem lies on the inner concave side of the xylem horseshoe. Lower down, where the horseshoe becomes a closed curve, the protoxylem comes to be surrounded by wood, so that here we have a certain resemblance to the *Lyginodendron*-bundle, though perhaps only an accidental one ‖. The more pronounced mesarch character of the xylem in *Todea superba* and *T. hymenophylloides* offers a still closer agreement with the primary xylem of *Lyginodendron* than is afforded by *Osmunda*.

A comparison as regards the disappearance of the protoxylem strands in the lower part of their course has been made by Scott ¶ between *Osmunda* and *Poroxylon*, another member of the Palæozoic Cycadofilices.

The unfortunate scarcity of petrified plants of Mesozoic age almost restricts us to evidence afforded by carbonized fronds, but the preservation is frequently good enough to furnish trustworthy data. Towards the close of the Palæozoic period the records of plant-life become very meagre, and it is not until the latter part of the Triassic period, and in rocks of Rhætic age, that we find an assemblage of fossils comparable with the wealth of material from Permo-Carboniferous beds.

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* Bower (1891).

† Zeiller (1890), fig. 11, p. 16.

‡ Stur (1885), p. 150.

§ Zeiller (1899), p. 18.

‖ Williamson & Scott (1895), p. 667.

¶ Scott (1900), p. 403.

There is no doubt that the Osmundaceous type was abundantly represented in the vegetation of the Rhætic period. We can detect no essential difference between various fronds of Rhætic age and others from different Jurassic horizons *. It is enough for our purpose to draw attention to some of the more important facts bearing on the past history of the Osmundaceæ, without entering into a detailed systematic examination of fossil records. We use the specific name *Todites Williamsoni* in a comprehensive sense as standing for a well-marked central type of frond, including both Rhætic and Jurassic forms, which are no doubt not always specifically identical.

TODITES WILLIAMSONI †. (Pl. 27. figs. 1, 8, 9, 11, 13.)

1828. *Pecopteris Williamsoni*, Brongniart, Hist. vég. foss. p. 324, pl. 110. figs. 1 & 2.
P. whitbiensis, id. ibid. p. 321, pl. 109. fig. 204.
1829. *P. recentior*, Phillips, Geol. Yorks. p. 148, pl. 8. fig. 15.
1833. *Neuropteris recentior*, Lindley & Hutton, Foss. Fl. vol. i. pl. 68.
1835. *Pecopteris dentata*, id. ibid. vol. iii. pl. 169.
1836. *Acrostichites Williamsoni*, Göppert, Foss. Farn. p. 285.

The bipinnate fronds of this species (Pl. 27. fig. 1 & 11) are characterized by the broad straight rhachis bearing long linear pinnæ of uniform breadth which gradually taper to an acuminate apex. The pinnules are attached by a broad base and closely set on the pinnæ; they are slightly falcate, the side towards the rhachis is strongly convex, and the outer margin is straight or concave and bulged outwards towards the base of each segment.

The fertile pinnules have usually the same form as the sterile, their under surface being covered with large spherical sporangia (Pl. 27. fig. 13). Well-preserved sporangia have been described by Schenk ‡ from Rhætic examples from Persia, and by Raciborski § (Pl. 27. figs. 8 & 9) from specimens from Lower Jurassic beds near Cracow. We have found equally good sporangia on fertile specimens (*e. g.* Pl. 27. fig. 11) from the Inferior Oolite rocks on the Yorkshire coast. The sporangia agree in the absence of an annulus, as well as in their form and manner of dehiscence, with the Osmundaceous type.

In the fossil fronds the fertile pinnules are very numerous, and the sporangia usually cover the whole of the under surface of the lamina. It is noteworthy that Mesozoic Ferns often appear to have been more richly supplied with sporangia than their modern representatives. This is the case as regards *Todites* and the fossil species of Matonineæ ||.

The following incomplete list serves to illustrate the abundance of *Todites* in both the Rhætic and the higher Jurassic strata :—

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* Seward (1900), p. 39.

† For other figures, see Seward (1900), pls. 14, 15, 21.

‡ Schenk (1887), pl. 3. fig. 3.

§ Raciborski (1894), pl. 6.

|| Seward (1899).

SPECIES.	Geological horizon.	Geographical distribution.
Todites Williamsoni	Jurassic.	England.
Acrostichites linnææfolia, Rog.[1]	Rhætic.	N. America (Virginia).
A. rhombifolius, Font.	„	„ „
Todea Williamsoni[2]	Jurassic.	Poland.
Acrostichites Goeppertianus (Muenst.)[3]	Rhætic.	Germany.
„ „	„	Scandinavia.
„ *Williamsoni*[4]	„	Persia.
„ „	Jurassic.	Russia.
Pecopteris whitbiensis, Brongn.[5]	„	China.
Todea Williamsoni[6]	„	Greenland.
Asplenium whitbiense[7]	„	Siberia.
Dichopteris microphylla, Zigno[8]	„	Italy.
Asplenium whitbiense[9]	„	Japan.
Cladophlebis virginiensis, Font.[10]	„	N. America.

[1] Fontaine (1883). [2] Raciborski (1894). [3] Schenk (1867), pls. 5 & 6.
[4] Eichwald (1866), pl. 2. fig. 3. [5] Schenk (1883). [6] Hartz (1896), pl. 12. [7] Heer (1877).
[8] Zigno (1856), pl. 15. fig. 5. [9] Yokoyama (1889), pl. 2. fig. 3. [10] Fontaine (1889), pl. 3.

Attention has elsewhere * been drawn to the confusion that exists in palæobotanical literature between the true *Todites* and several of the bipinnate fronds described under such names as *Pecopteris whitbiensis*, &c. The specimens described by Brongniart in 1828 as *Pecopteris denticulata*, and now referred to the genus *Cladophlebis*, may be taken as typical of a form of a fern-frond very widely spread in Mesozoic floras. Without entering further into the question of synonymy, we would draw attention to the occasional occurrence of fertile pinnæ (Pl. 27. fig. 4) which there is good reason to believe belong to *Cladophlebis denticulata*. This species has been doubtfully referred to the Polypodiaceæ †, but in the absence of well-preserved sporangia its systematic position must remain doubtful; on the other hand, the resemblance between the fossil specimen shown in fig. 4 and the fertile pinnæ of *Todea barbara* suggests the possibility that *Cladophlebis denticulata* may possibly be another Jurassic member of the Osmundaceæ. While agreeing closely in form with *Todites Williamsoni*, the fronds of *Cladophlebis denticulata* may usually be recognized by the longer and more falcate pinnules, which may have an entire or denticulate margin. The variation in the character of the ultimate segments of *Todea barbara* (Pl. 27. figs. 2, 3, 4) finds a parallel among the Mesozoic types. We do not for a moment suggest that the superficial resemblance between the fertile pinnæ of the fossil fern with those of *Todea barbara* (*cf.* Pl. 27. figs. 2 & 4) constitutes a valid argument in favour of an Osmundaceous affinity, but it would seem to be at least as likely that *Cladophlebis denticulata* may be a member of the Osmundaceæ as of the Polypodiaceæ.

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* Seward (1900), p. 89.

† Seward (1900), p. 143, pl. 20. figs. 3 *a*, 3 *b*.

Several Tertiary plants have been referred to the Osmundaceæ, partly on evidence afforded by anatomical structure and partly on the grounds of resemblance in the form of the fronds. A well-preserved stem was described by Carruthers[*] in 1870 as *Osmundites Dowkeri*; the specimen, which was probably from Lower Eocene beds, was found on the shore of Herne Bay. The structure of the stem and leaf appears to be very similar to that of recent Osmundaceæ, but we have not enough data before us to enter into a more minute anatomical comparison. Carruthers describes the adventitious roots as arising from the interpetiolar spaces, and not from the base of each petiole. It is clear that the fossil stem is that of an Osmundaceous fern constructed on the same general plan as the existing forms. Another Tertiary stem very like *Osmundites Dowkeri* was described by Unger in 1854[†] from a Tertiary locality in Hungary as *Osmundites schemnicensis*, this generic name being substituted for *Asterochlæna*, which had been applied to the same plant by Pettko[‡].

A petrified Osmundaceous stem in the British Museum (Botanical Department) from New Zealand exhibits the same type of structure as that of *Todea*; the stele contains 8-9 xylem groups, some of which are small and oval, while others form long sinuous bands. Unfortunately the geological horizon of the specimen is not recorded.

The fronds[§] of Tertiary age referred to the Osmundaceæ need not be dealt with, as they are few in number and usually founded on sterile and imperfect specimens. *Osmunda regalis* is recorded from the Norwich forest-bed[‖], and its frequent occurrence in newer submerged forests affords an indication of the wide distribution of this species in Europe in post-Tertiary days.

THEORETICAL CONSIDERATIONS AND CONCLUSIONS.

Reference has already been made to the divergent interpretations of the Osmundaceous type of stem-anatomy. In instituting a comparison of the structure of filmy Ferns with such species as *Todea barbara* and the representatives of *Osmunda*, it must be remembered that we are comparing plants which have acquired different characters in response to dissimilar external conditions—a fact that increases the difficulty of discriminating between features of primary phylogenetic importance and such as may be described as merely the expression of adaptation to environment. It is indeed impossible to draw a definite line of separation between characters that mark evolutionary progress, and structural peculiarities that reflect the plasticity of a plant in its response to the stimulus of external conditions.

In *Osmunda Claytoniana*[¶] the stem is characterized by the large number of xylem strands—in well-nourished plants there are usually about forty; in *O. cinnamomea* the medullary rays, and therefore the xylem strands, are much fewer; *O. regalis* possesses an intermediate number of strands—usually about fifteen. In *Todea barbara* the xylem groups do not exceed eight, at least in the stems we have examined; in *T. hymenophylloides* the number is approximately the same; while in *T. superba* the xylem occasionally forms an unbroken cylinder. The medullary parenchyma is widest in *Osmunda Claytoniana* and most reduced in *Todea superba*. The position of the protoxylem also varies: in *Osmunda* the spiral elements are usually on the inner edge of the metaxylem, but in *Todea*, especially in the filmy species, the xylem is mesarch, while in *T. hymenophylloides* some of the strands are almost exarch. Another feature of importance is the presence of an internal endodermis in *O. cinnamomea* and *T. hymenophylloides*; and in the former species internal phloem has been found in several specimens examined by Jeffrey and Faull.

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[*] Carruthers (1870).

[†] Unger (1854).

[‡] Pettko (1850).

[§] See Gardner (1879), p. 49, pl. 4.

[‖] Carruthers (1870); Reid (1899), pp. 91, 96; Solms-Laubach (1891), p. 172.

[¶] Faull (1901).

Irregular and inconstant groups of sclerous cells occur in the centre of the medullary region in the stems of *Osmunda regalis*, *O. cinnamomea*, *T. barbara*, and *T. hymenophylloides*. The internal endodermis, like the sclerous cells, is not always present in the same stem, and both kinds of tissues are characterized by a sporadic manner of occurrence. If we were familiar only with *Osmunda regalis* and *Todea barbara* we should naturally describe the Osmundaceous stem as possessing a medullated monostele, but in the internal endodermis of *Osmunda cinnamomea*, Jeffrey and Faull recognize evidence which leads them to abandon this simple interpretation. These authors describe the Osmundaceous stele as a reduced form of an amphiphloic siphonostele[*]. This brings before us a wide question, the discussion of which depends primarily upon the value to be attached to the endodermis as a layer of supreme morphological importance. The well-known cases of *Equisetum*[†] and *Ranunculus*[‡] illustrate the difficulty of adopting the endodermis as the determining factor in morphological decisions; it was this difficulty that led Strasburger to depart from the definition of Van Tieghem and others, who recognize in the endodermis the innermost layer of the cortex, and, as such, a layer which may be accepted as a safe guide in defining the boundaries of stelar and extrastelar regions. Strasburger substituted the term phloeoterma, to be used in a strictly morphological sense, retaining the term endodermis as a designation of histological but not necessarily of any morphological significance. An *Equisetum* stem with a special endodermis round each vascular bundle may be regarded as monostelic, the layers of cells with suberized walls being merely portions of stelar conjunctive tissue modified for a special physiological purpose.

The view taken of the stelar structure of the Osmundaceæ depends to a large extent on the importance to be attached to the internal endodermis of *Osmunda cinnamomea* and *Todea hymenophylloides*. Faull states that an internal endodermis is present in the medullary region of both young and old stems; he notes the close structural agreement between the inner and outer endodermis of *Osmunda cinnamomea*, and draws attention to the fact that both endodermal layers become continuous through the ramular, and occasionally through the foliar, gaps. The occurrence of sclerous cells in the centre of the stem is adduced as another argument against including the axial tissues within the stelar area, and in support of this view Faull adds that sclerenchymatous elements are not found in the stele of other ferns.

We are disposed to take the view that the medullary tissue is not homologous with the cortical tissues, but that it forms part of the stele. The endodermal layer of *Todea hymenophylloides*, which makes its appearance here and there in the medullary region and is not found in the seedling stem, may be regarded as a specially modified part of the stelar conjunctive tissue.

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[*] Jeffrey (1899); Faull (1901).

[†] Pfitzer (1867); Strasburger (1891), p. 434.

[‡] Marié (1885).

We are as yet but imperfectly acquainted with the physiological importance of endodermal layers; Schwendener's interesting paper * on this subject demonstrated the plasticity of the endodermis as an adaptation to diverse conditions; but we need further experimental work to enable us to understand the physiological functions of endodermal tissue. It is well known that similar tissues may be produced in regions morphologically distinct. The mere structure of a cell-layer is not a safe guide to morphological value. The lining layers in the gaps in the leaf of *Monstera* are epidermal in structure, but they are not derivatives of a dermatogen. We believe that the view of Jeffrey and Faull involves an assumption for which we lack adequate reasons.

In *Lyginodendron*, which in its primary xylem agrees closely with *Osmunda*, and even more closely with *Todea*, there is a ring of xylem surrounding a medullary region consisting of parenchyma and sclerous nests. The more typical *Lyginodendron* stem, with its separate mesarch xylem strands, suggests a comparison with *Todea barbara* and *T. hymenophylloides*, while those stems in which the xylem forms a more continuous band † may be compared with *Todea superba*. It is in the stele of this extinct member of the Cycadofilices that we recognize what we believe to be the type of structure most nearly allied to that of recent Osmundaceæ.

We wish to express our thanks to Mr. Lynch for the pains that he has taken to supply us with such material as we required.

[Since this paper was read Prof. Jeffrey's important memoir has been published in the Philosophical Transactions of the Royal Society: at the time of writing we had only the abstract before us, Jeffrey (1901).—*November*, 1902. A. C. S.]

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* Schwendener (1885).

† Williamson (1890), pl. 13. fig. 11; see also Williamson & Scott (1895), p. 721.

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EXPLANATION OF THE PLATES.

Plate 27.

Fig. 1. *Todites Williamsoni.* From a specimen in the Geological Museum, Cambridge.

Figs. 2 & 3. *Todea barbara.* From plants in the Kew Herbarium.

Fig. 4. *Cladophlebis denticulata.* From a specimen in the Geological Museum, Cambridge.

5. *Todea barbara.* From a plant in the Kew Herbarium.

6. *Kidstonia heracleensis.* Portion of fertile pinnule. (× 30.) After Zeiller.

7. *Kidstonia heracleensis.* Sporangium seen from the side. (× 40.) After Zeiller.

Figs. 8 & 9. *Todites Williamsoni.* Sporangia. (× 65.) After Raciborski.

Fig. 10. *Todea hymenophylloides.* Young plant.

11. *Todites Williamsoni.* Fertile frond: from a specimen in the Geological Museum, Cambridge.

12. *Discopteris Rallii.* Sporangium seen from above. (× 40.) After Zeiller.

13. *Todites Williamsoni.* Fertile pinnule. (× 4.) After Raciborski.

Plate 28.

Fig. 14. *Todea superba.* Transverse section through the outer part of the stele, near the apex of the stem. *en* = endodermis; *pr*, cells between the endodermis and the sieve-tubes (pericycle); *s–s*, sieve-tubes; *xp* = xylem-parenchyma; *mx* = unlignified metaxylem. (× 200.) Page 242.

15. *Todea hymenophylloides.* Transverse section near the apex of the stem. *px* = protoxylem. (× 200.) P. 242.

16. *Todea barbara.* Transverse section. *t* = innermost elements of the region *pr* of fig. 14, the tangentially elongated elements of Zenetti and the protophloem of Faull. (× 170.) P. 242.

17. *Todea hymenophylloides.* Transverse section through an older part of the stele than that from which fig. 15 was drawn. (× 170.) P. 249.

18. *Todea superba.* Diagrammatic sketch of part of a transverse section close to the apex of the stem. (× 15.) P. 242.

19. *Todea superba.* Transverse section through part of the stele close to the apex of the stem. None of the xylem elements are lignified. (× 120.) P. 242.

20. *Todea hymenophylloides.* Diagrammatic transverse sections of the young stele, showing the form of the xylem tissue.

21. *Todea superba.* Transverse section taken at a slightly lower level in the stem than that shown in fig. 19. (× 190.) P. 242.

22. *Todea hymenophylloides.* Transverse section of the stele near the tip of the primary root. (× 190.) P. 241.

23. *Todea superba.* Apical cell of the stem. (× 150.) P. 242.

24. *Todea hymenophylloides.* Transverse section at a slightly higher level than fig. 22. (× 190.) P. 241.

25. *Todea hymenophylloides.* Transverse section through the xylem and part of the phloem region of a young plant, at a higher level in the stele than fig. 24. *m* = pith. (× 200.) P. 241.

Plate 29.

Fig. 26. *Todea barbara.* Diagram of part of a transverse section of the stem. P. 243.

27. *Todea barbara.* Plan of the xylem strands in the stele. $n+1$—$n+11$ = leaf-traces; *px*, dotted lines showing the course of protoxylem strands.

Fig. 28. *Todea hymenophylloides.* Transverse section through the outer edge of the pith showing the cells of the internal endodermis, *en′*. *m* = pith-cells; *mx* = inner tracheids of the xylem.

29. *Todea superba.* Diagram of the stele in transverse section. *lt* = leaf-traces; *r* = roots; α = position of large tracheids. Pp. 243, 248.

30. *Todea superba.* Large tracheids, *x* (fig. 29, α), in longitudinal section. P. 248.

31. *Todea superba.* The large tracheids, *x*, in transverse section.

32. *Todea superba.* Transverse section near the base of the stem. *s* = sieve-tubes; *en*, position of the endodermis, the cells of which have been torn.

33. *Todea barbara.* Transverse section. Lettering as in previous figures. P. 245.

34. *Todea barbara.* Diagrammatic sketch of a radial longitudinal section through an outgoing leaf-trace and the outer edge of a medullary ray.

35. *Todea superba.* Diagram illustrating the exit of a leaf-trace. *s* = sieve-tubes.

36. *Todea barbara.* Transverse section in the protoxylem region of the young frond shown in Pl. **30.** fig. 51, cut at the level *a*. P. 248.

37. *Todea hymenophylloides.* Transverse section of the stele close to the base of a stem; cut from the same stem as that represented in the other figures of this species.

38. *Todea barbara.* Diagram to show the passing out of a leaf-trace. *s′* = group of sieve-tubes. This figure represents the appearance of a section through *a b* in fig. 34.

39. *Todea barbara.* Diagrammatic sketch of a transverse section at a slightly higher level than fig. 38 (*c d*, fig. 34).

40. *Todea barbara.* Two of the sieve-tubes, *s′*, of fig. 39.

Plate **30.**

Fig. 41. *Todea superba.* Transverse section showing the xylem of the stele as a continuous band.

42. *Todea barbara.* Lettering as in previous figures.

43. *Todea hymenophylloides.* Transverse section through the pith. *sl* = sclerous group in the centre.

44. *Todea hymenophylloides.* The stele in transverse section. *en*, *en′* = outer and inner endodermis.

45. *Todea barbara.* Portion of the stele of a leaf in transverse section. *px* = protoxylem; *c* = groups of mucilage-sacs.

46. *Todea hymenophylloides.* A leaf-trace surrounded by an endodermal layer, *en*, leaving the stele of the stem.

47. *Todea hymenophylloides.* Part of a transverse section of the stele near the apex of the stem.

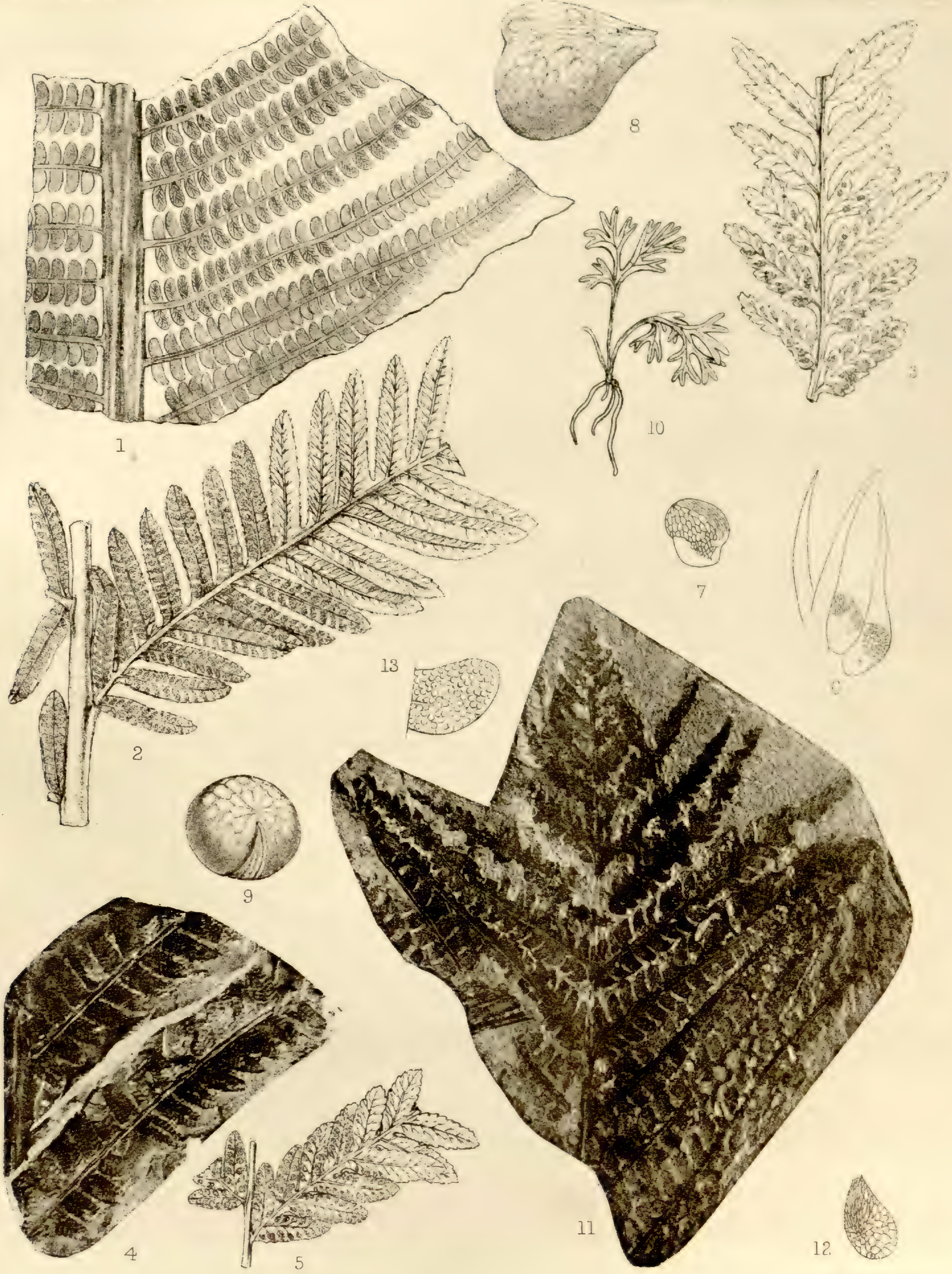
48. *Todea hymenophylloides.* Transverse section through a young stem, at a slightly higher level than fig. 25, Pl. **29.**

49. *Todea hymenophylloides.* Transverse section.

50. *Todea barbara.* Radial longitudinal section through an outgoing leaf-trace, *lt*, and part of the xylem, *st*, left in the stele; *sl*, sclerous element; *rt*, tracheids passing out to a root.

51. *Todea barbara.* Apex of frond. *h* = filamentous hairs.

52. *Todea barbara.* Transverse section through the stele of a small "crown" attached to a large plant.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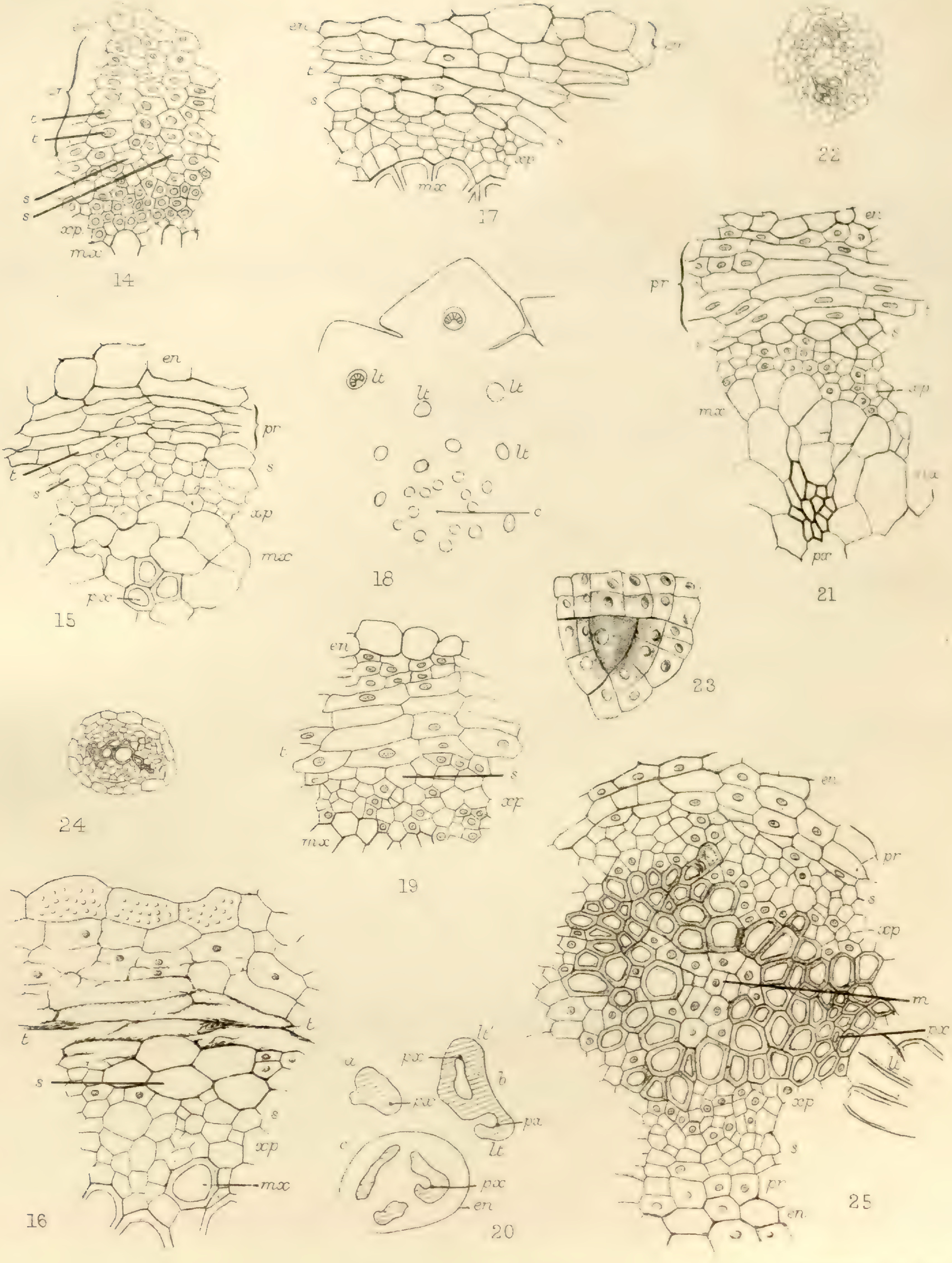
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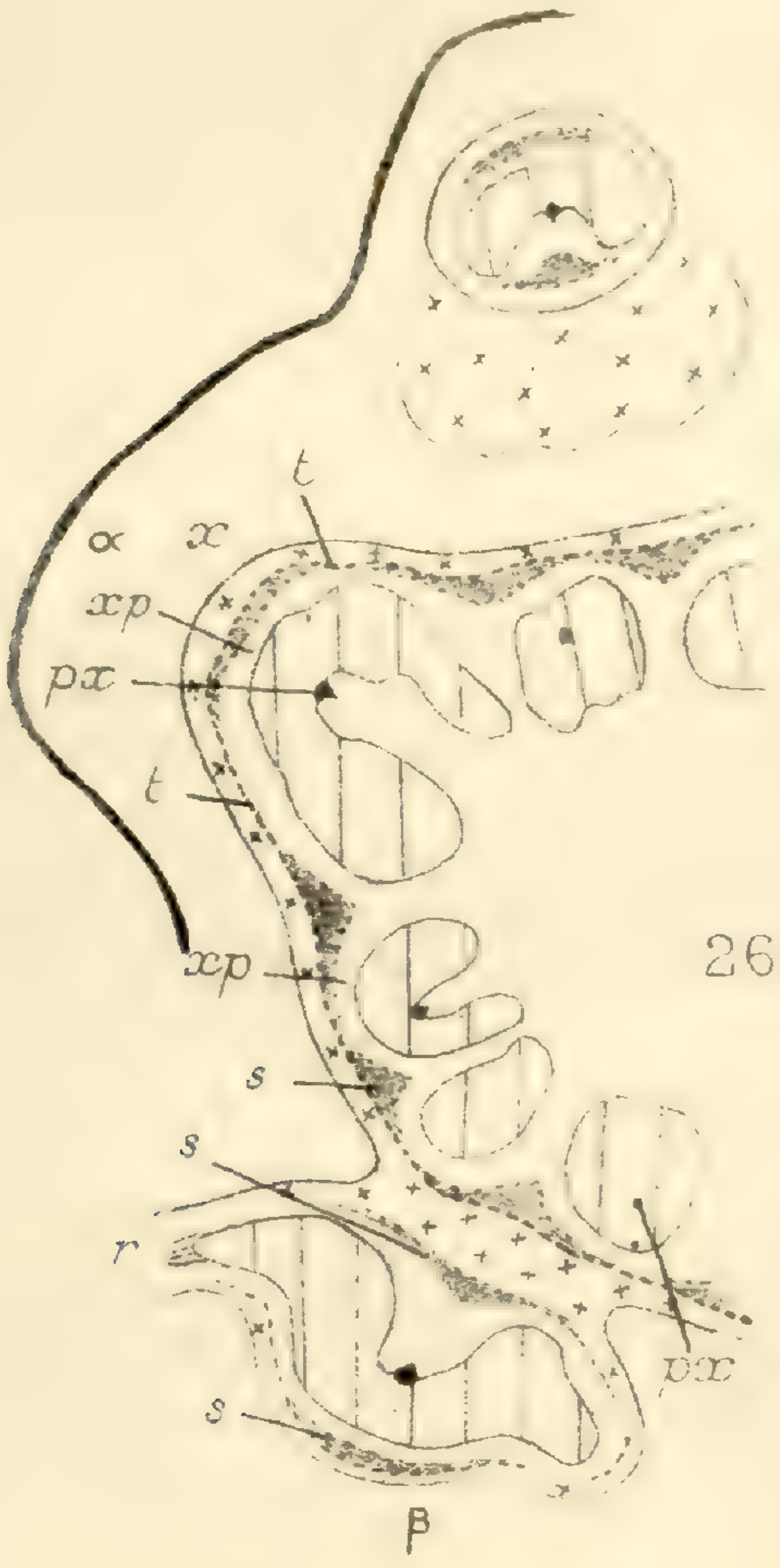
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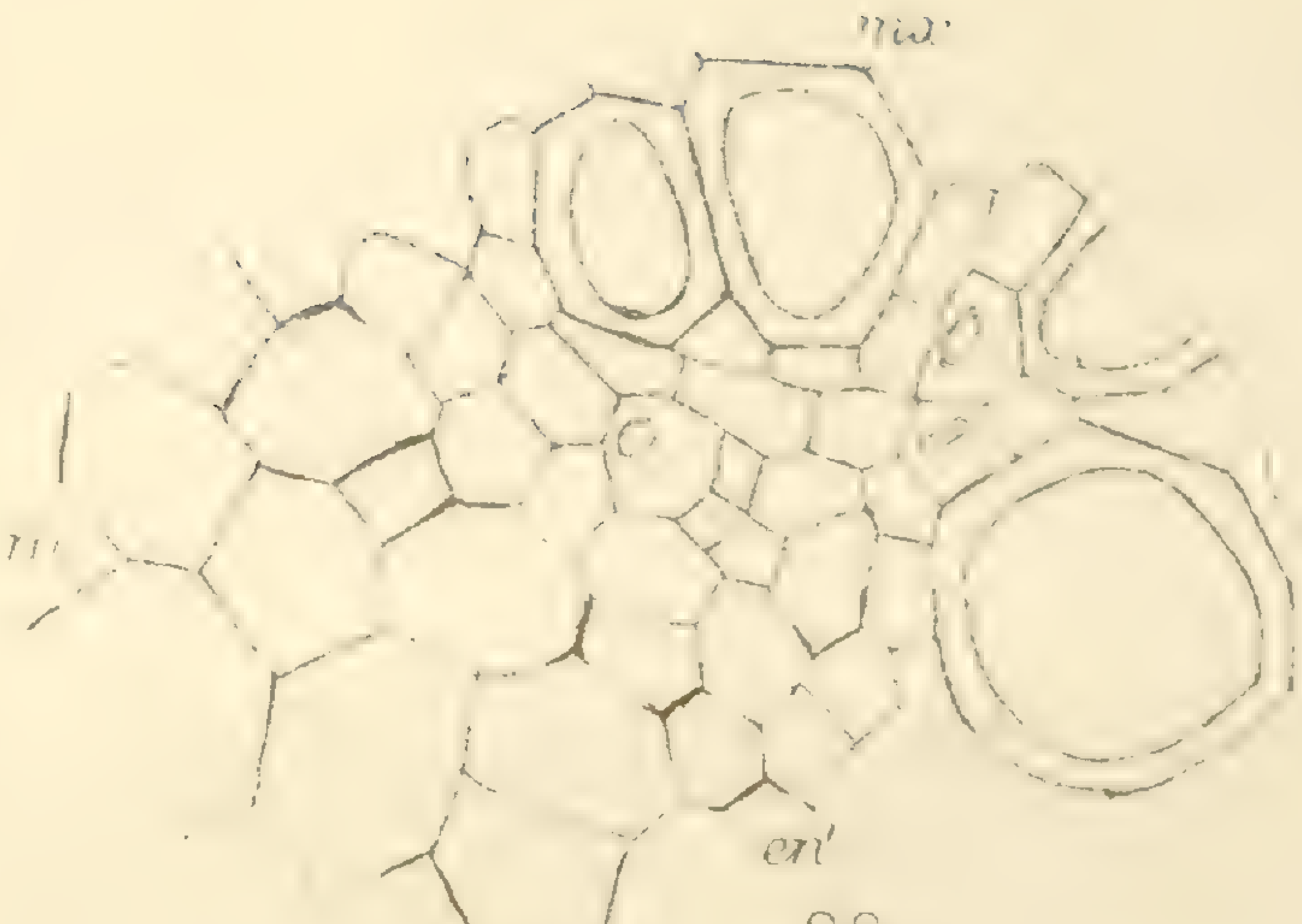

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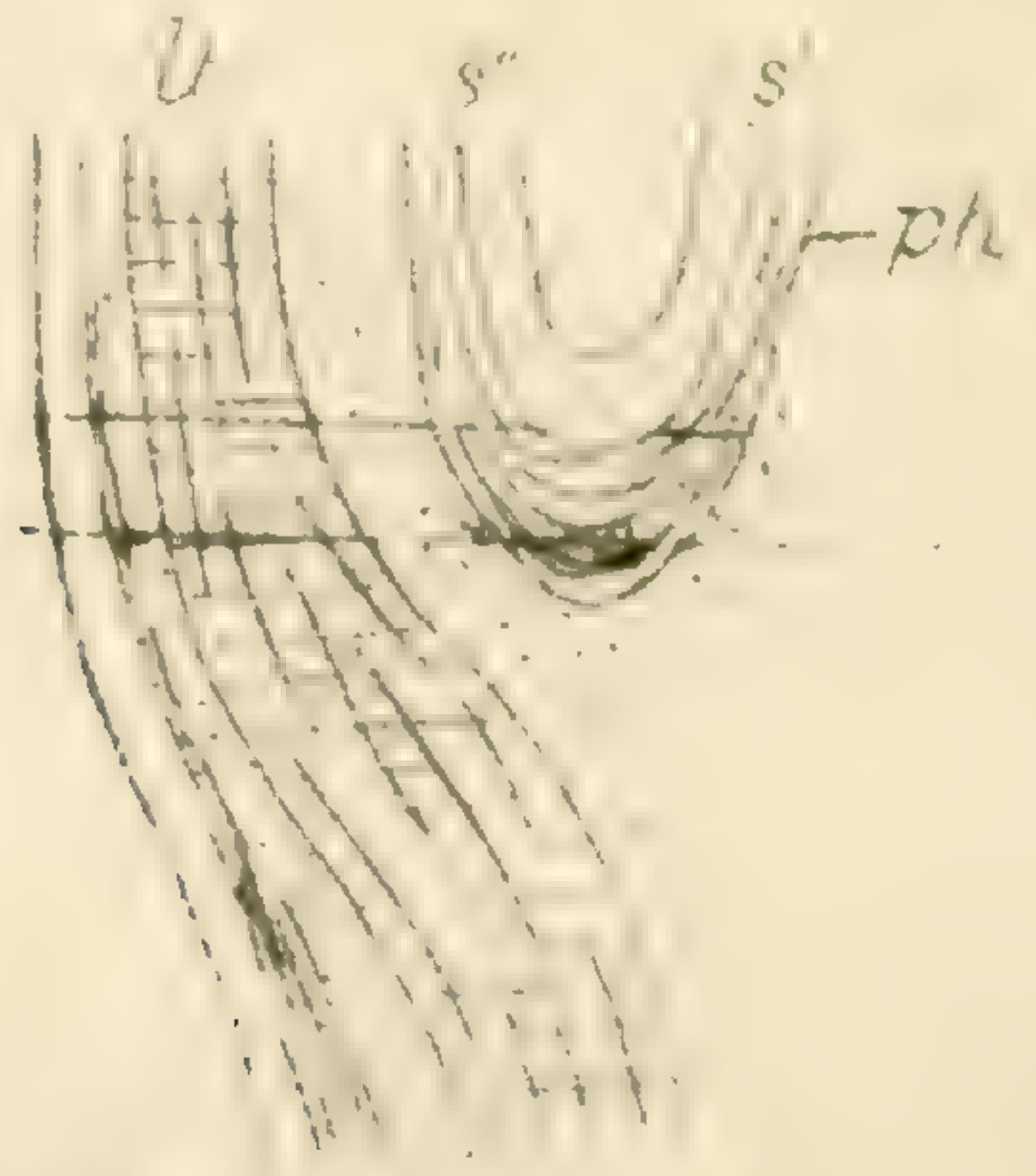

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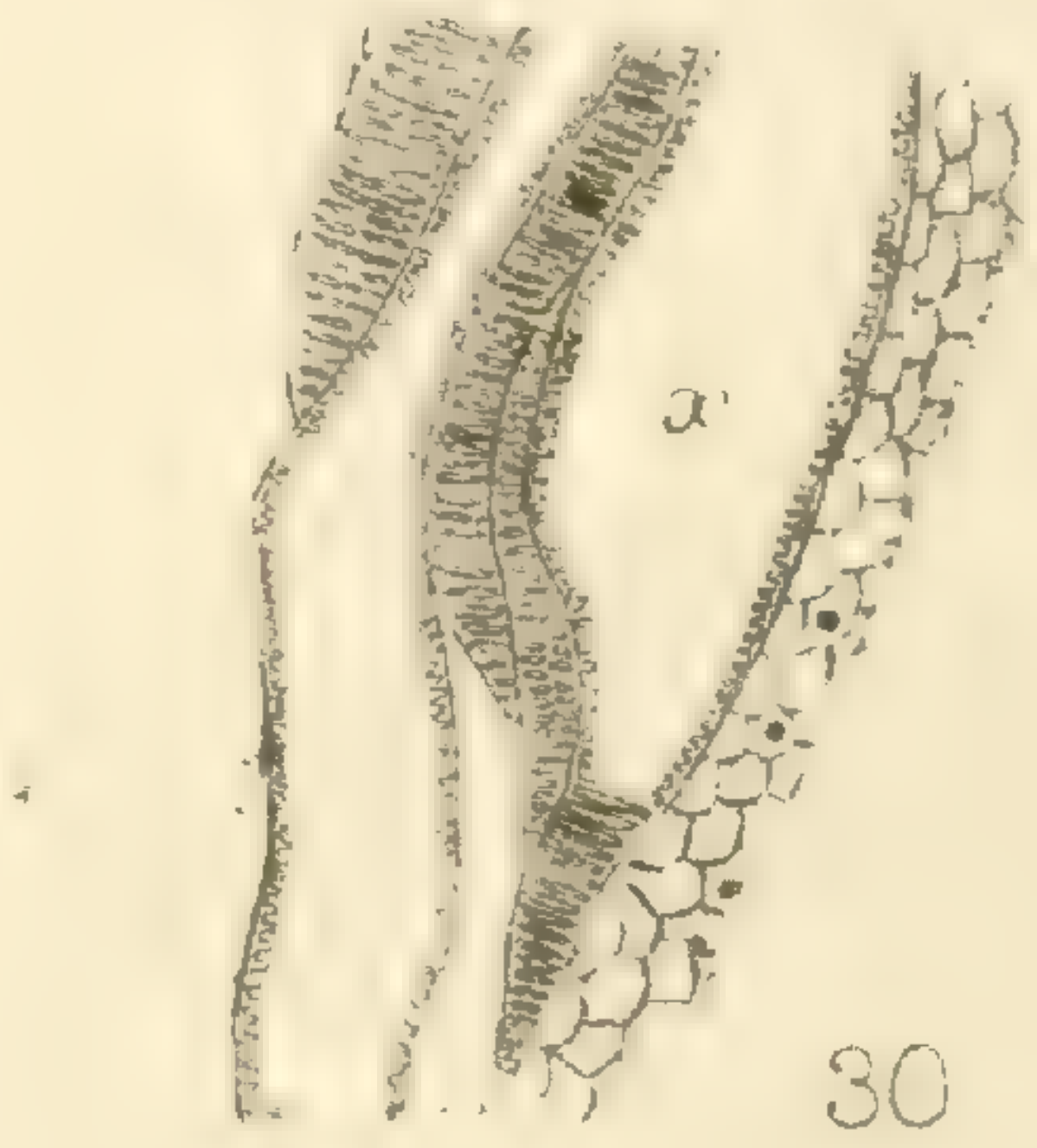

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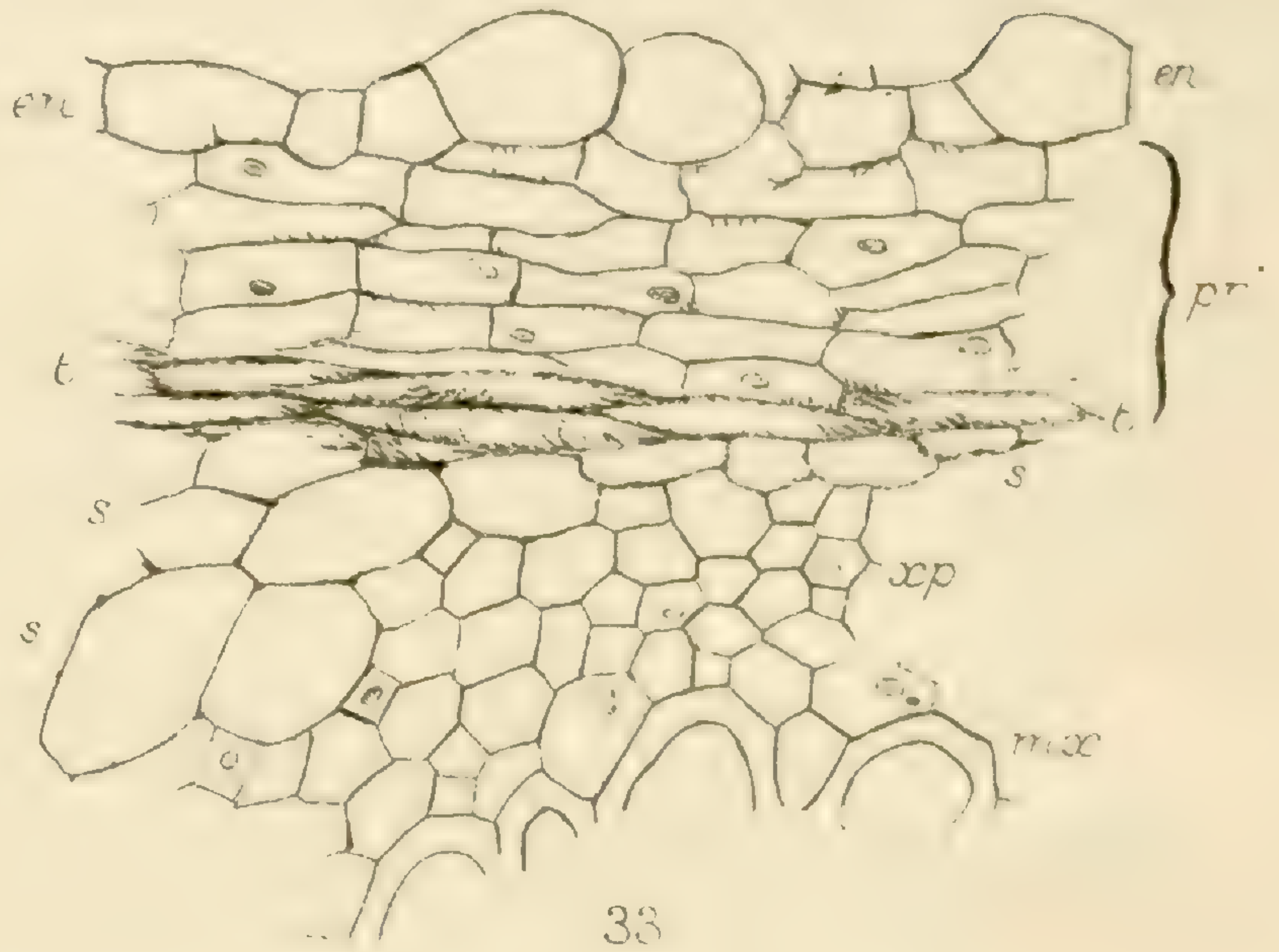
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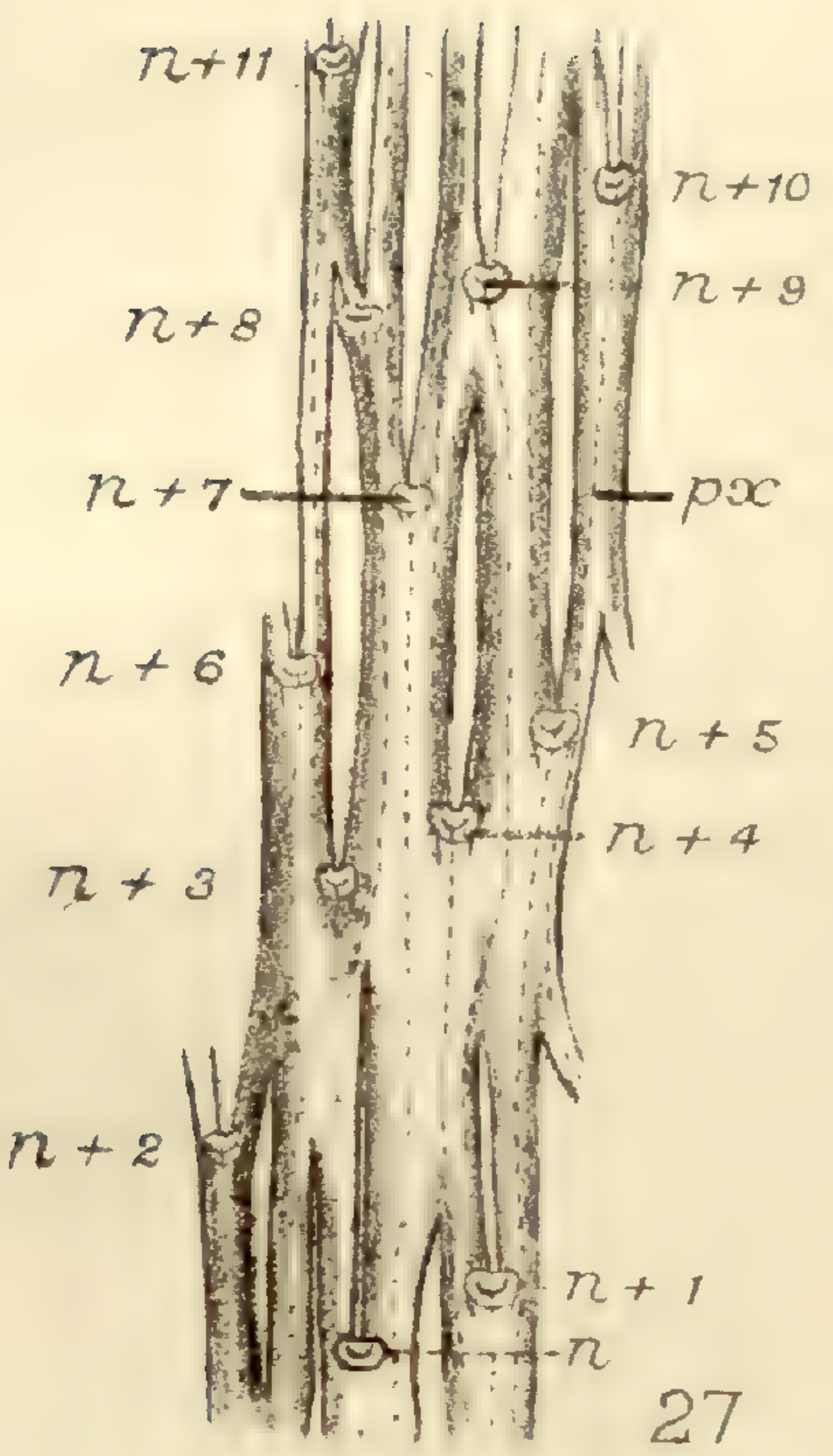
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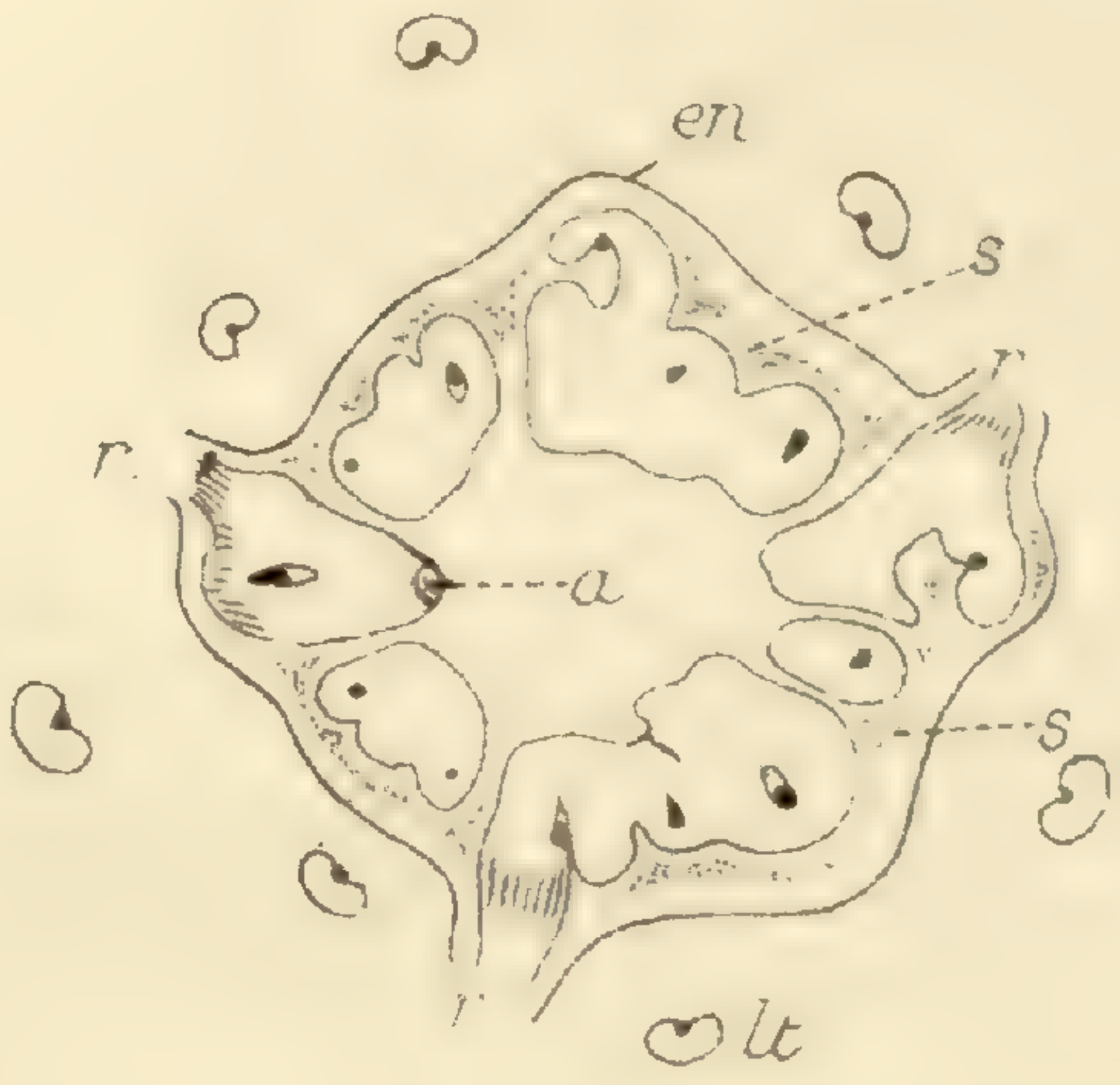
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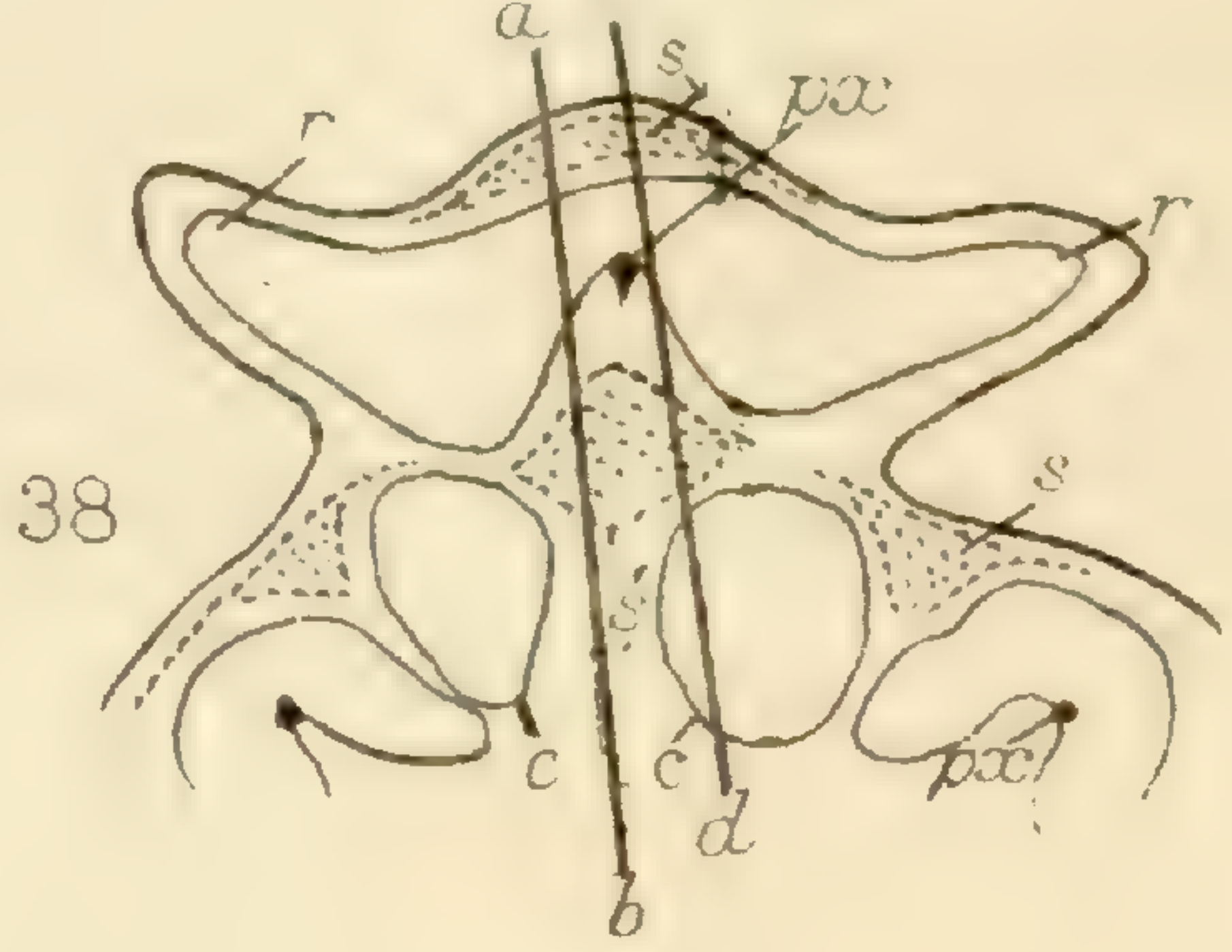
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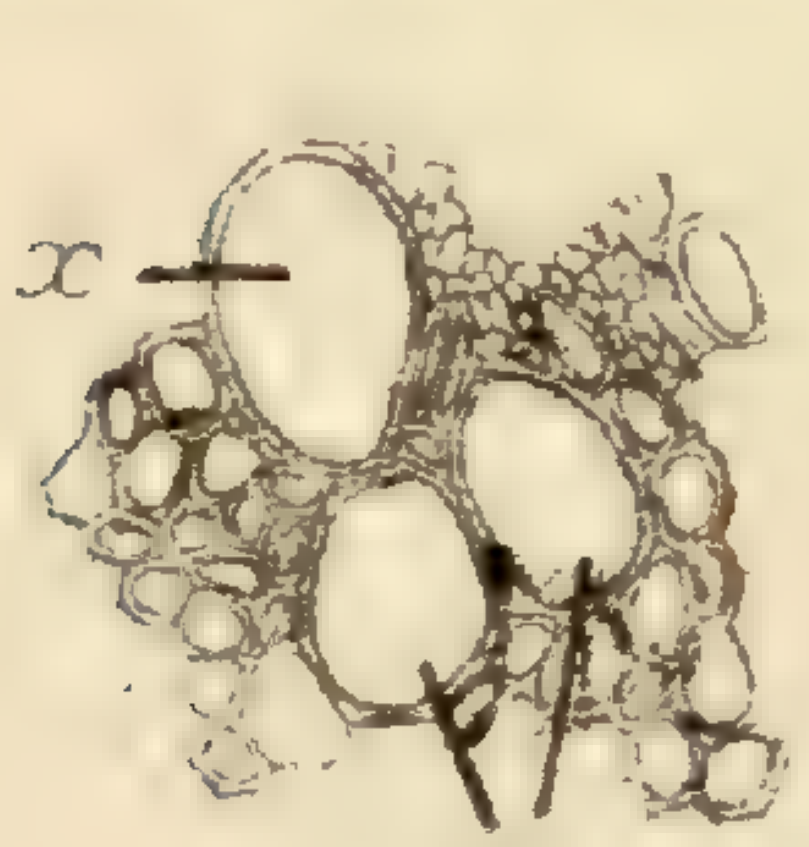

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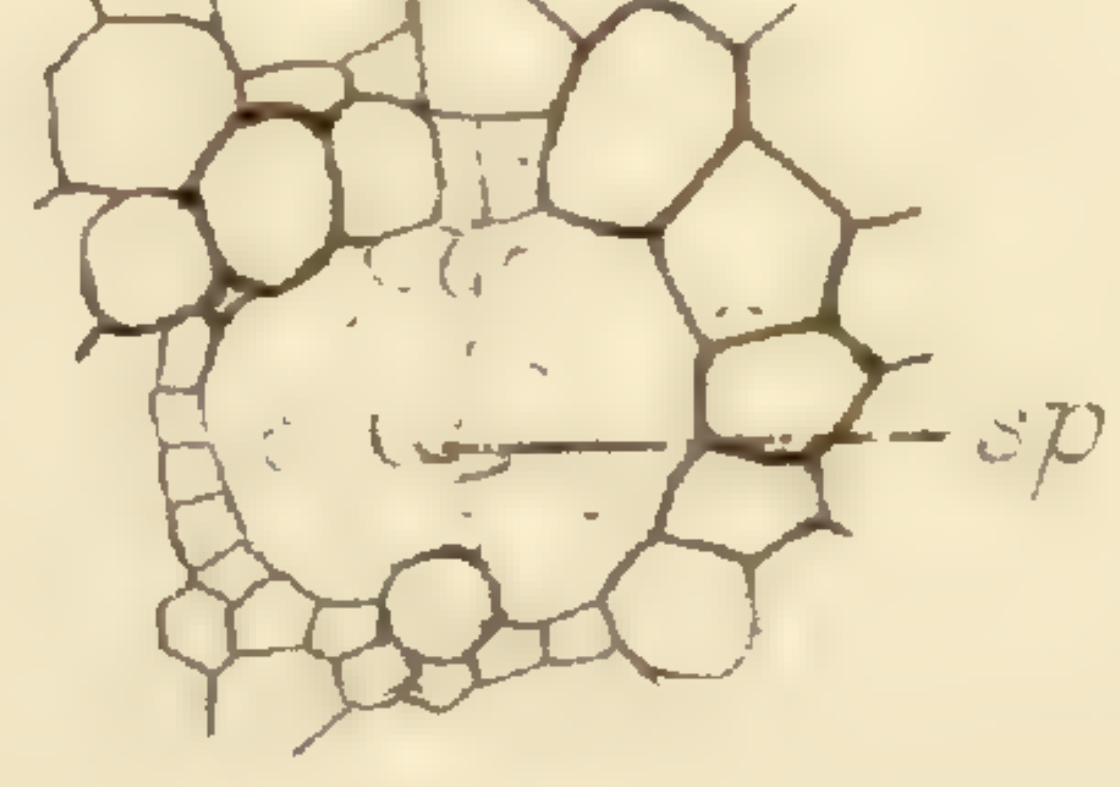

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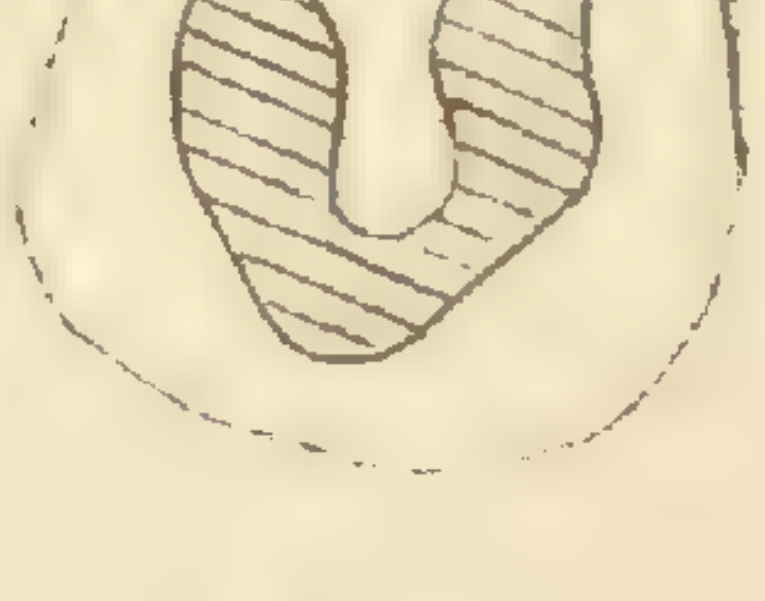

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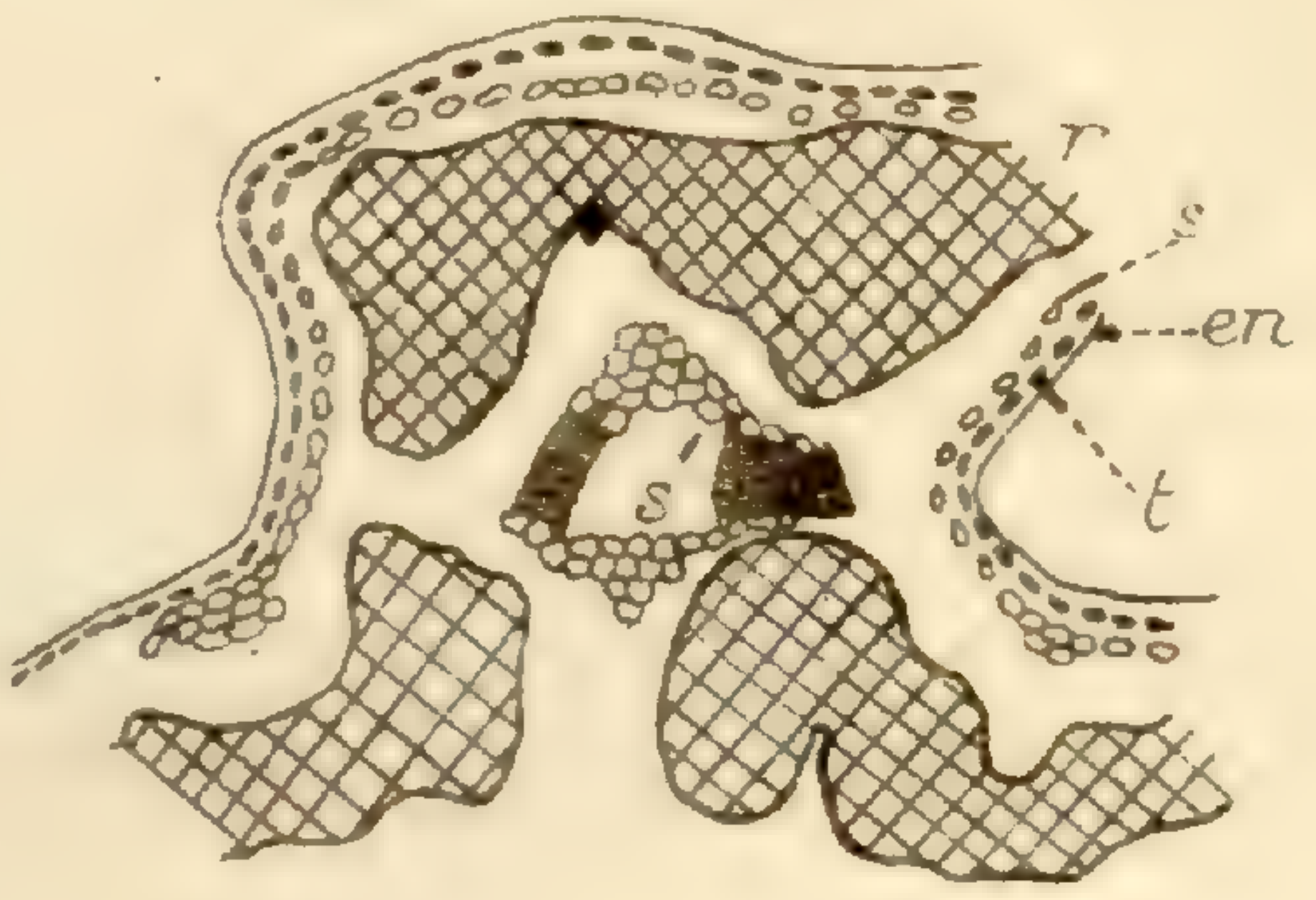

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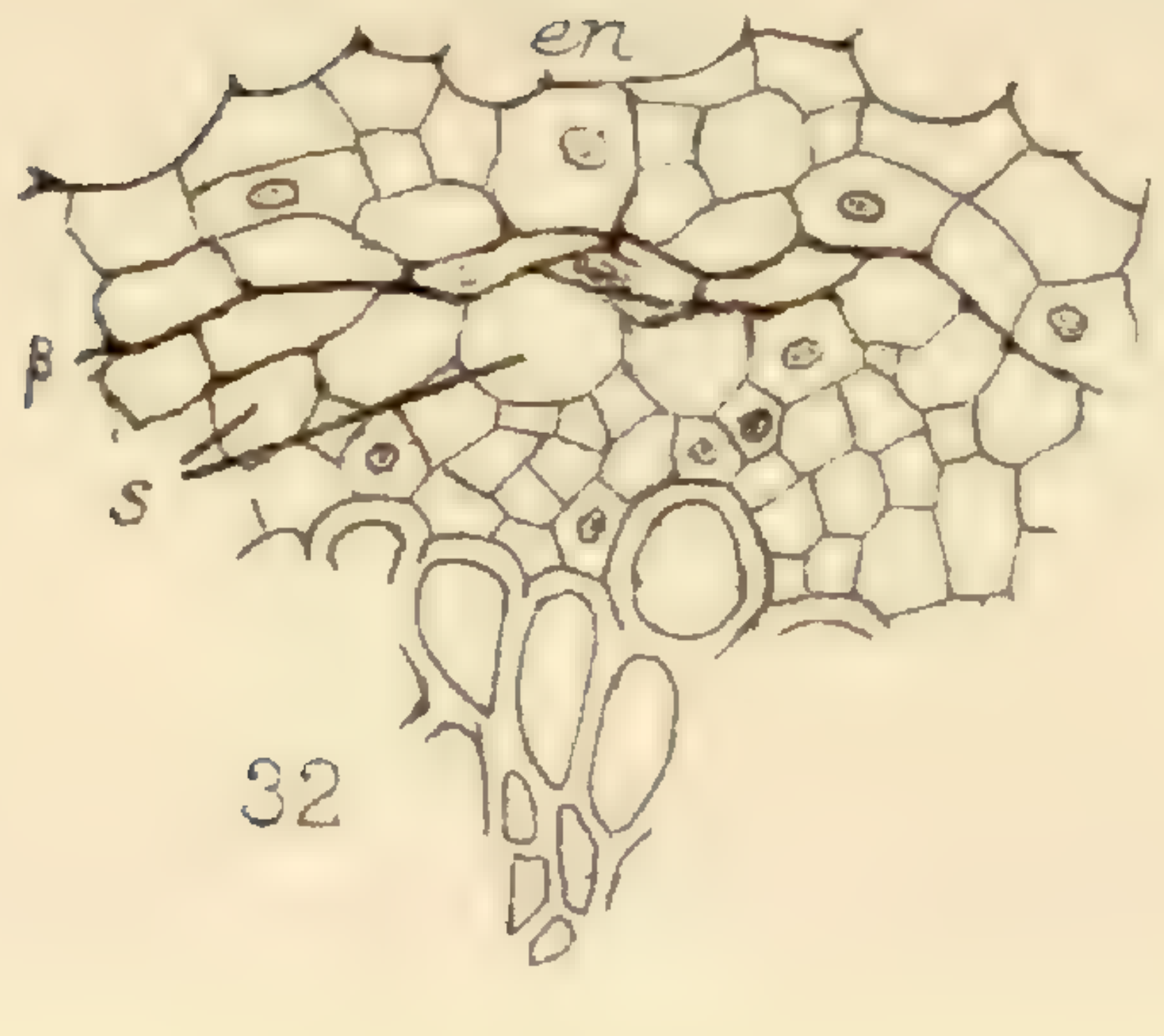

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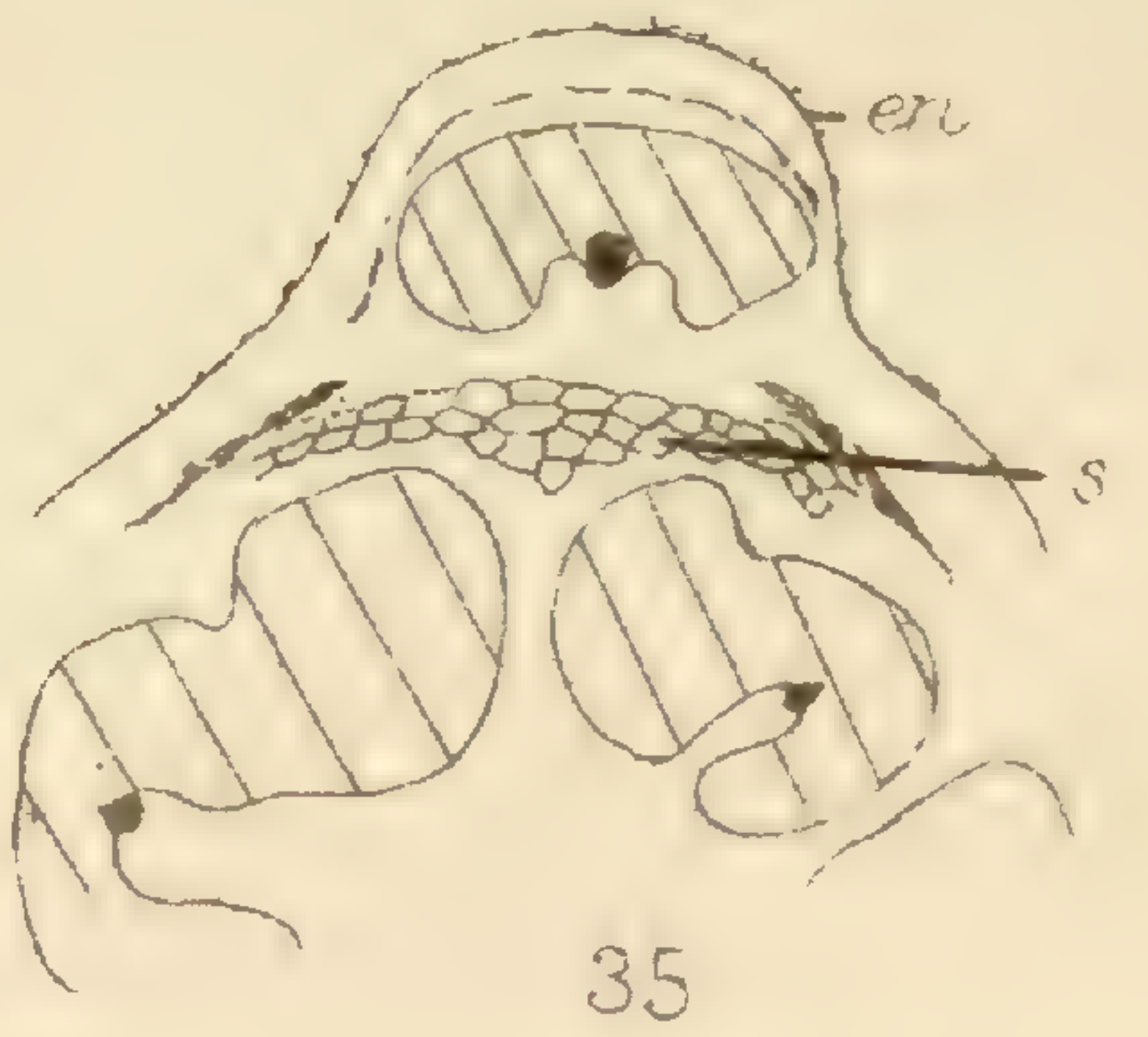

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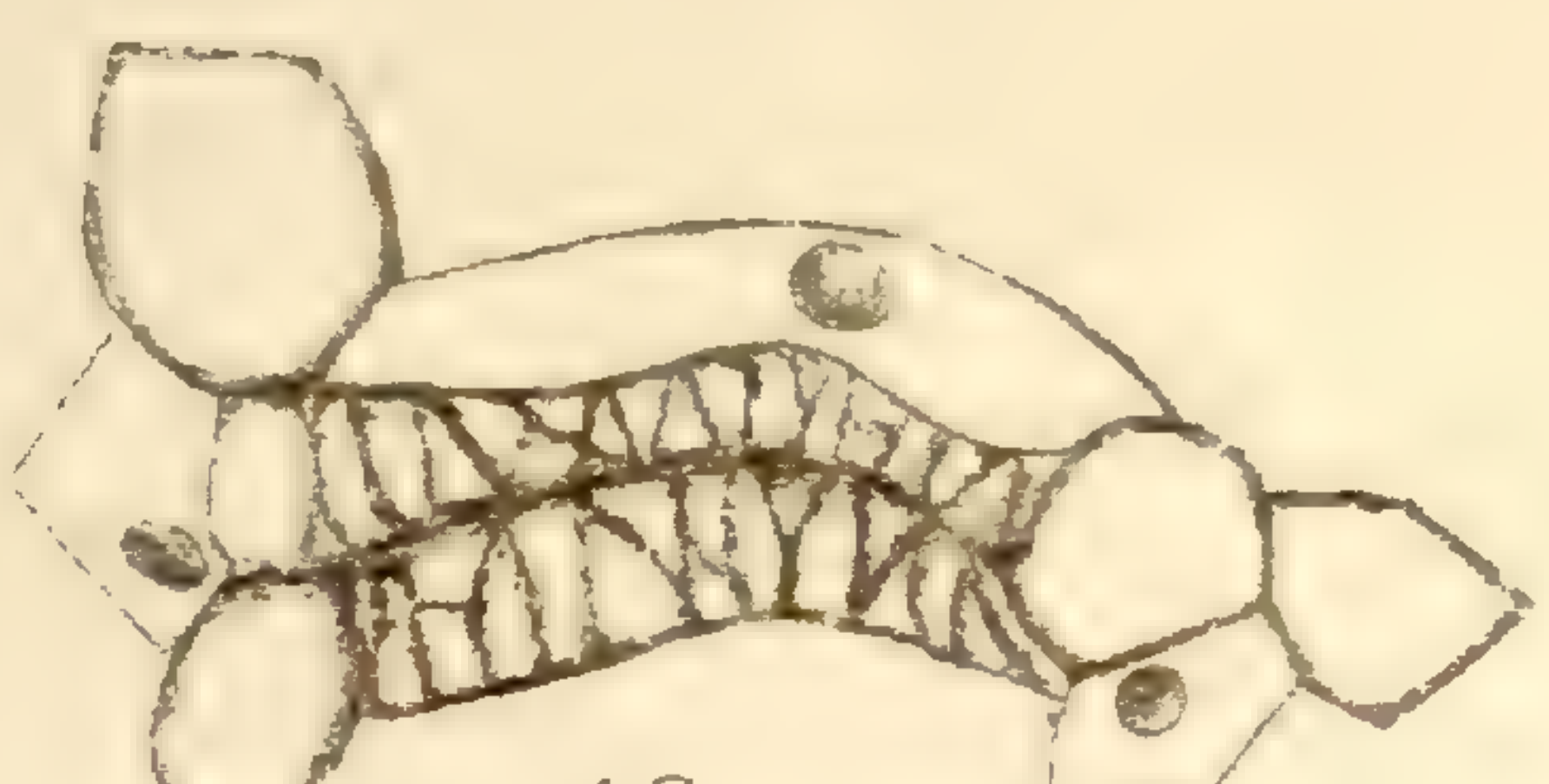

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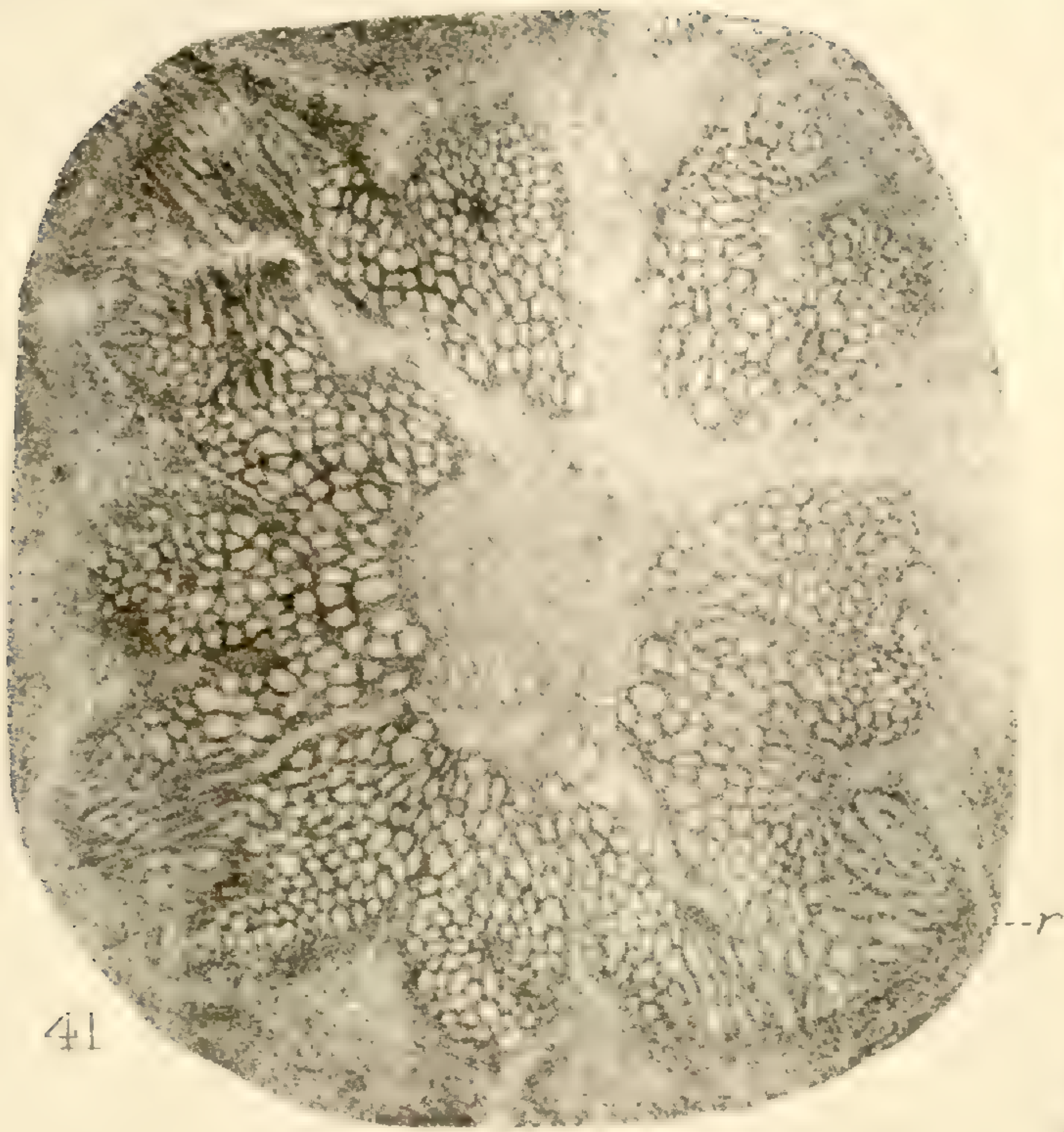
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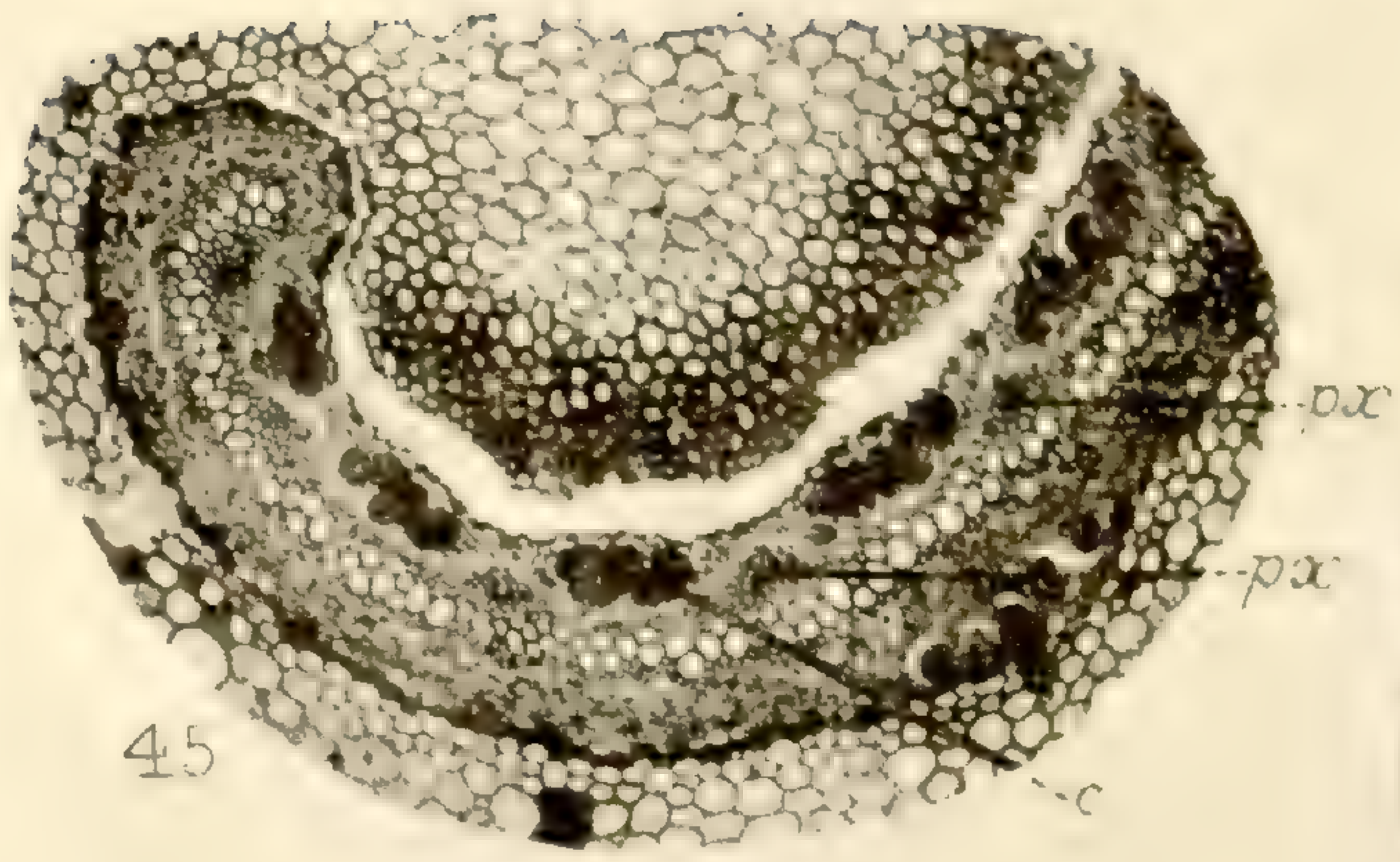
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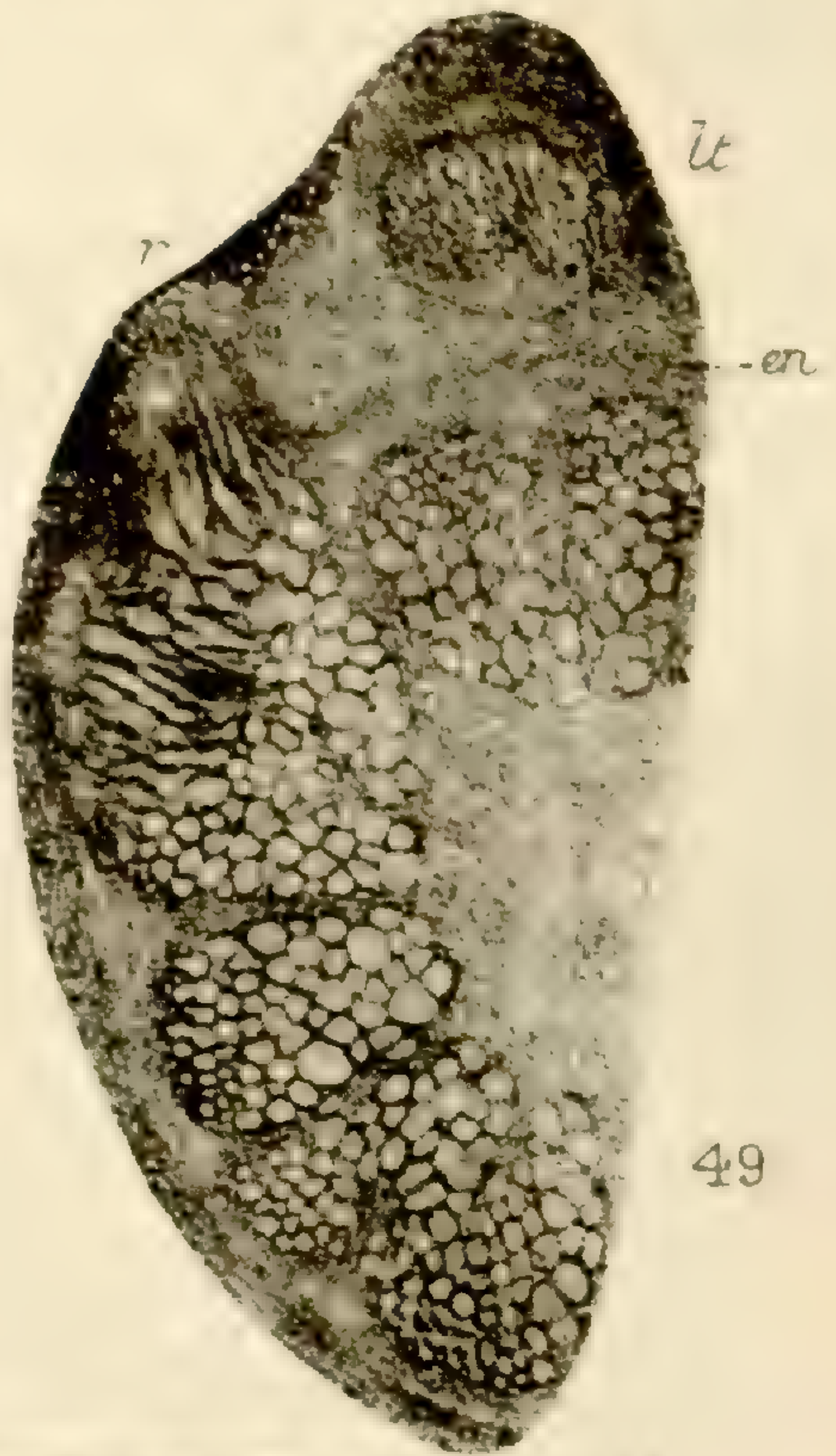
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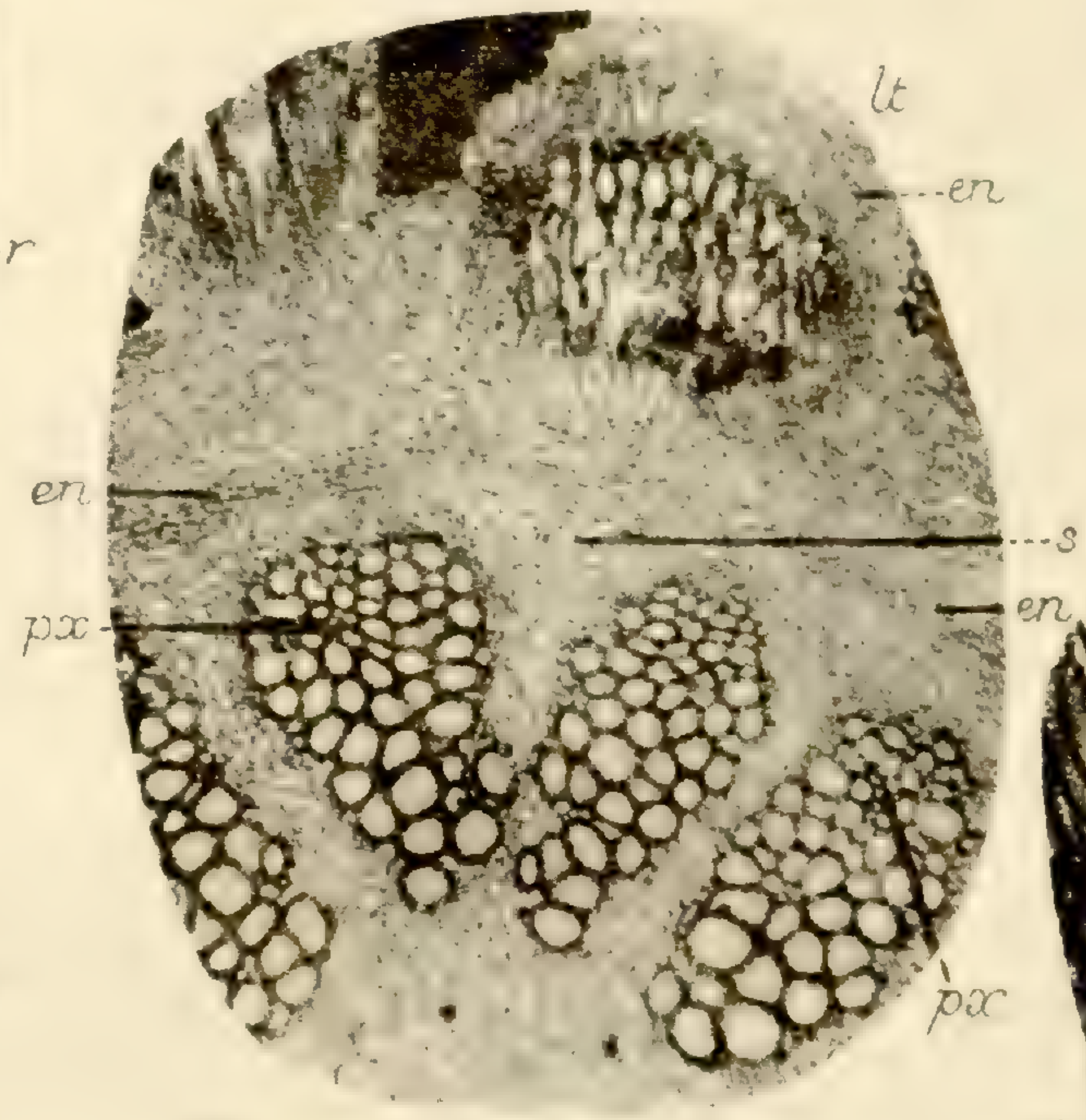
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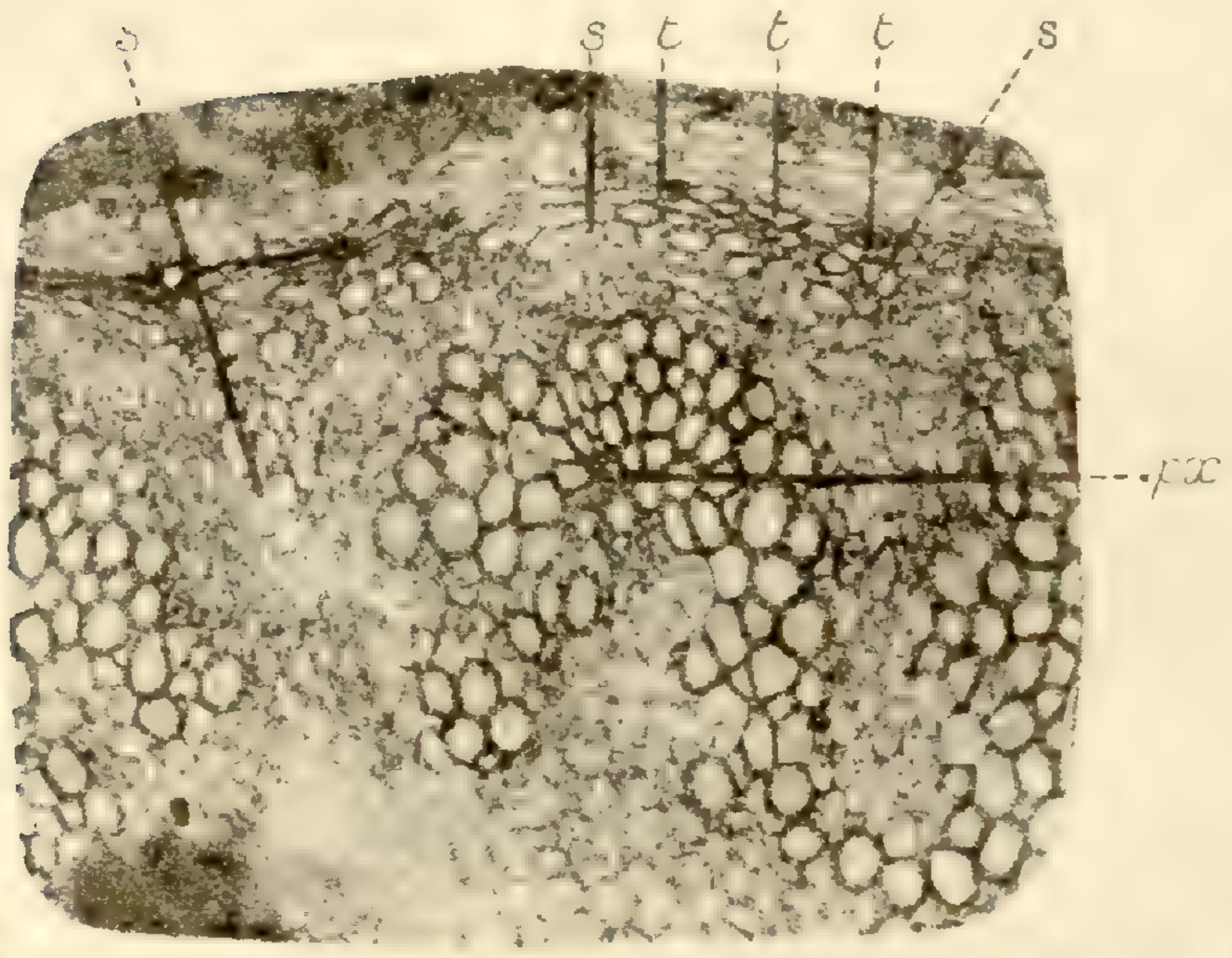
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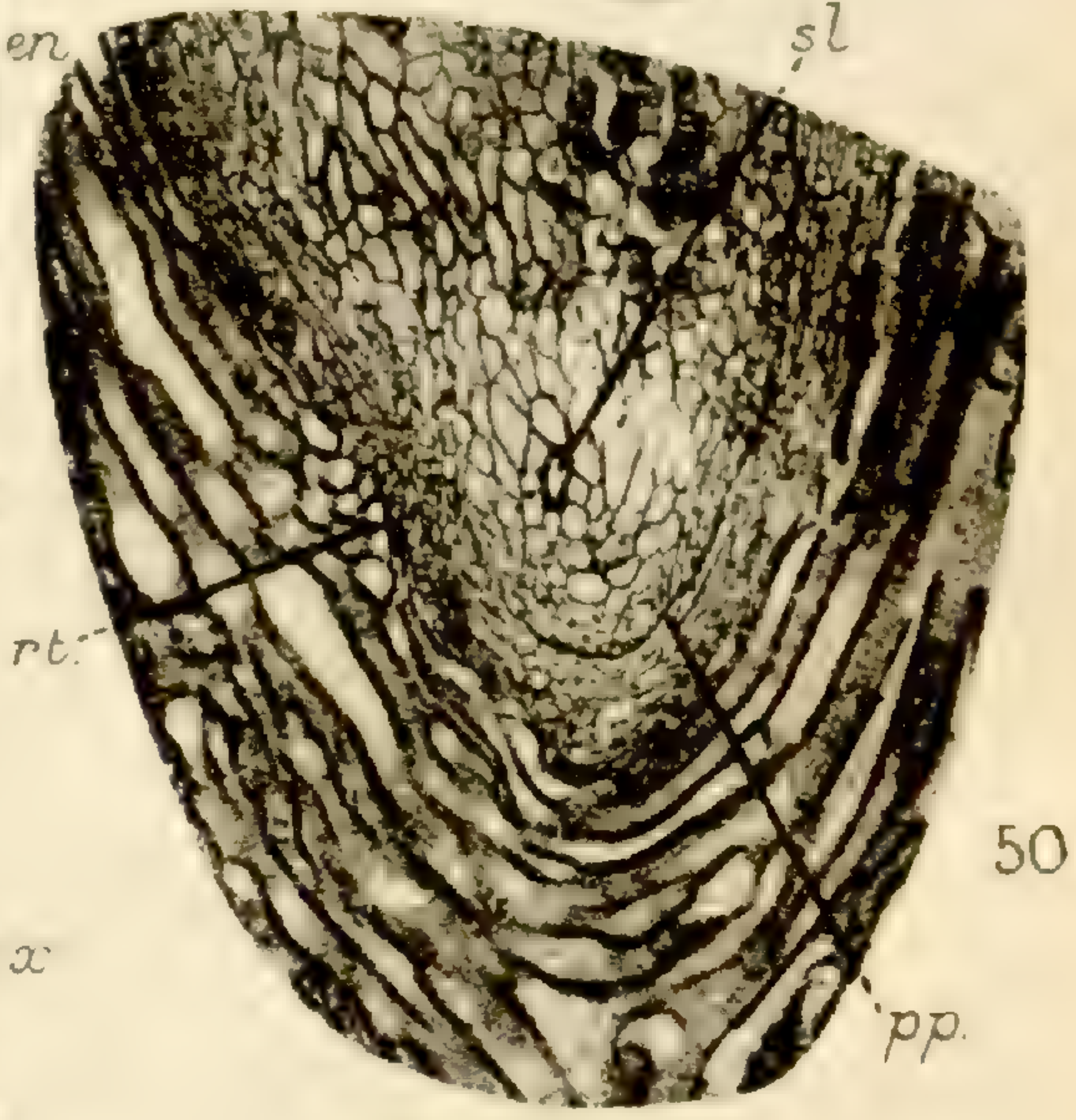
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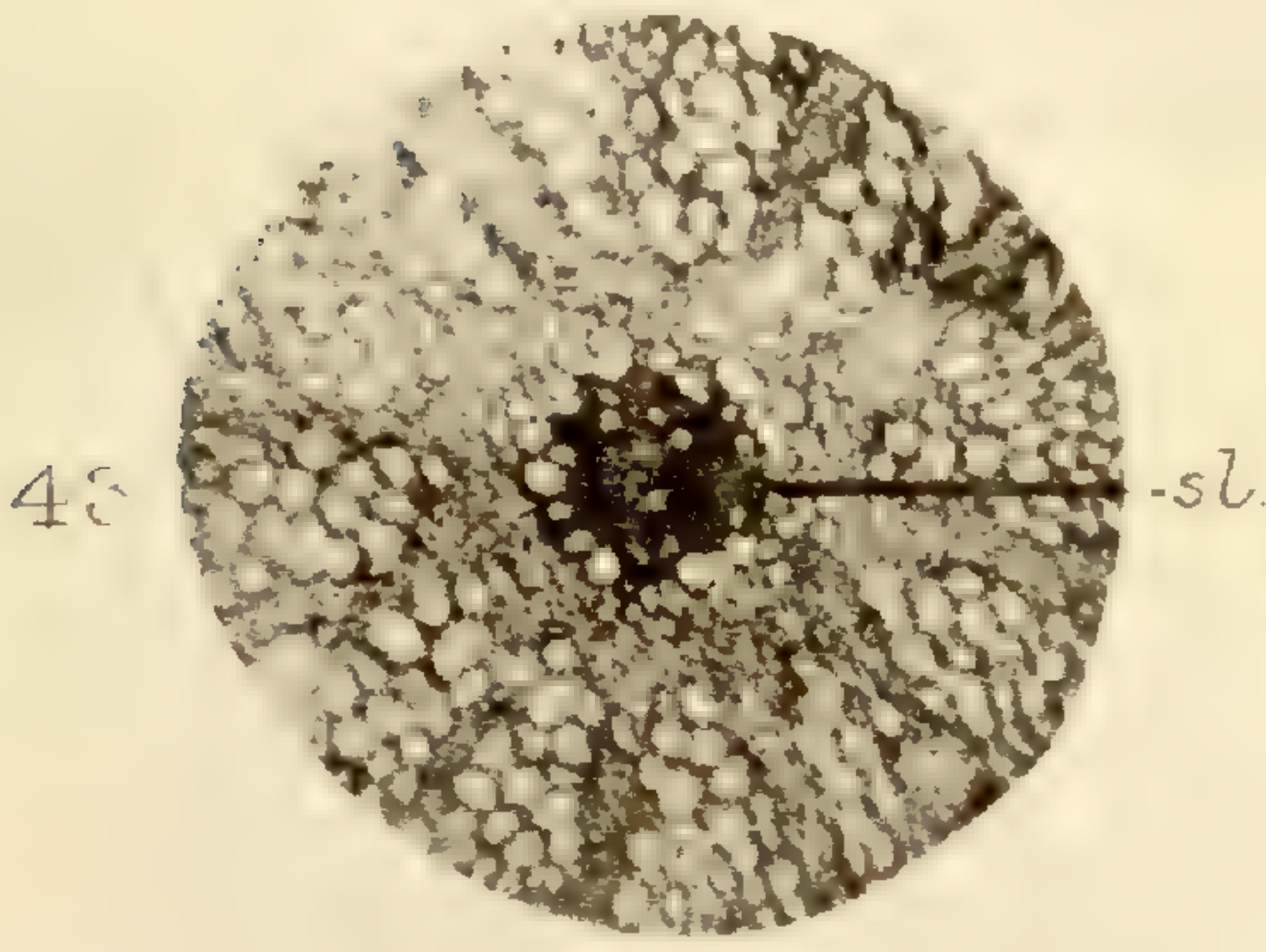
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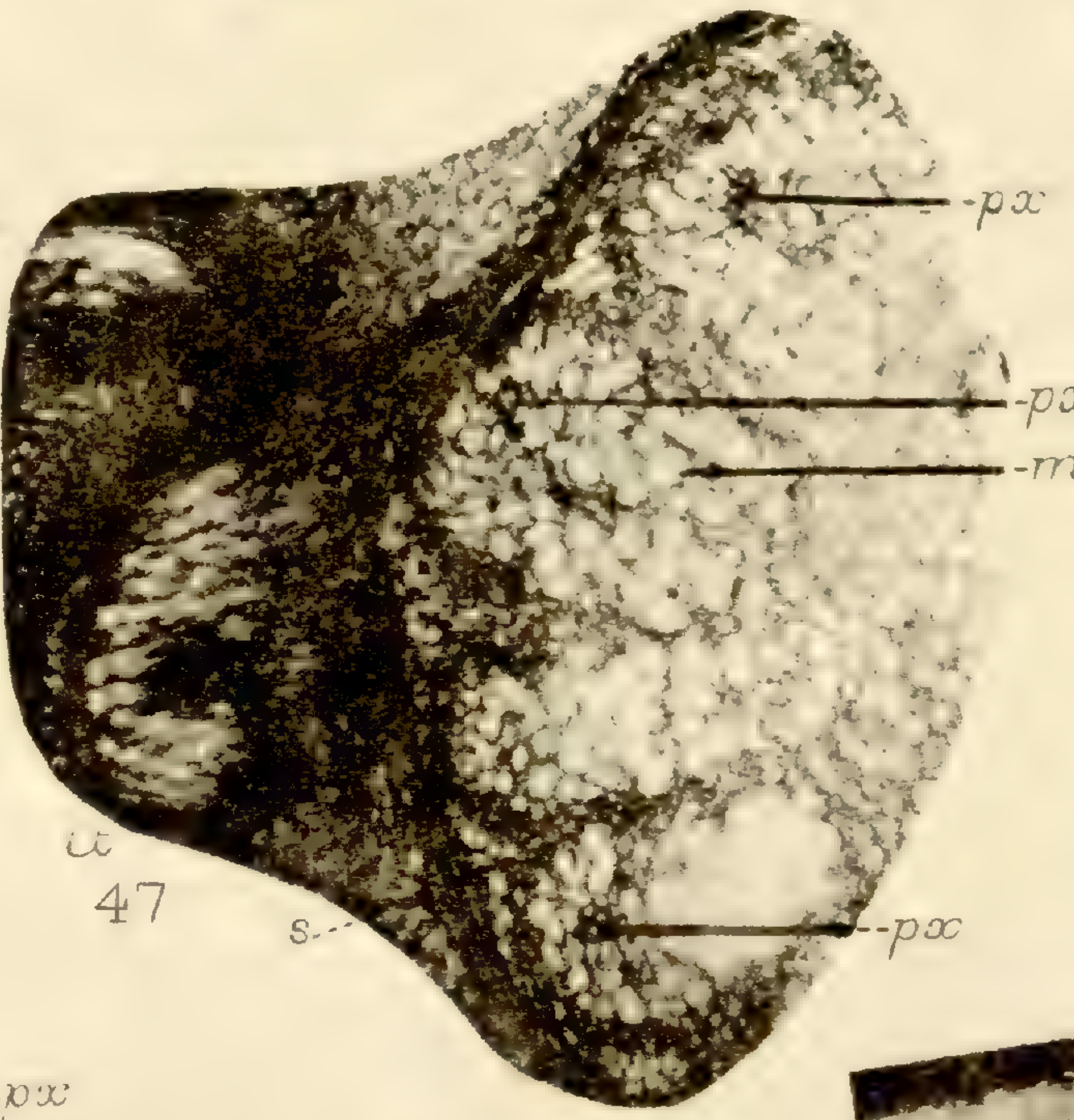
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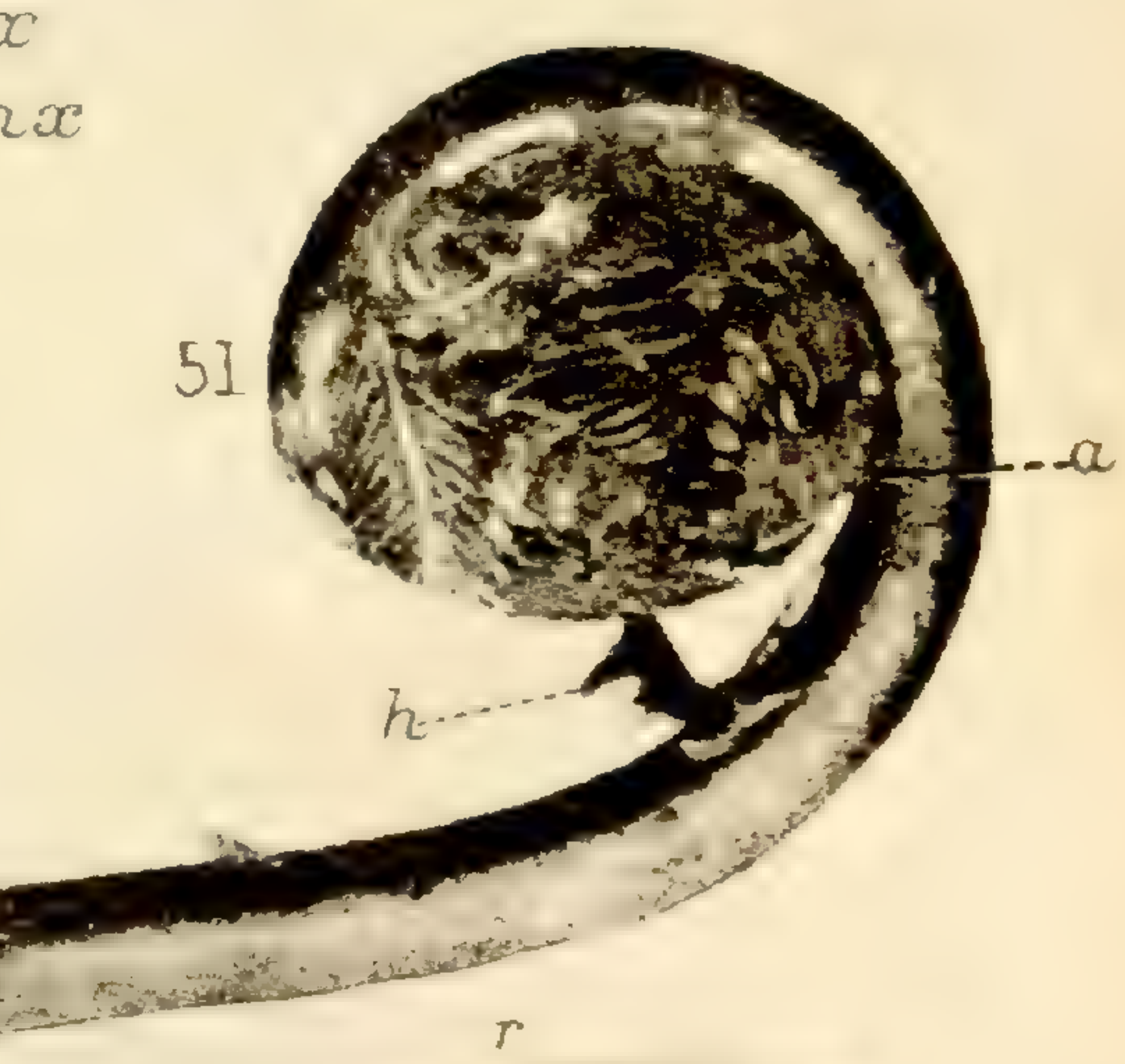
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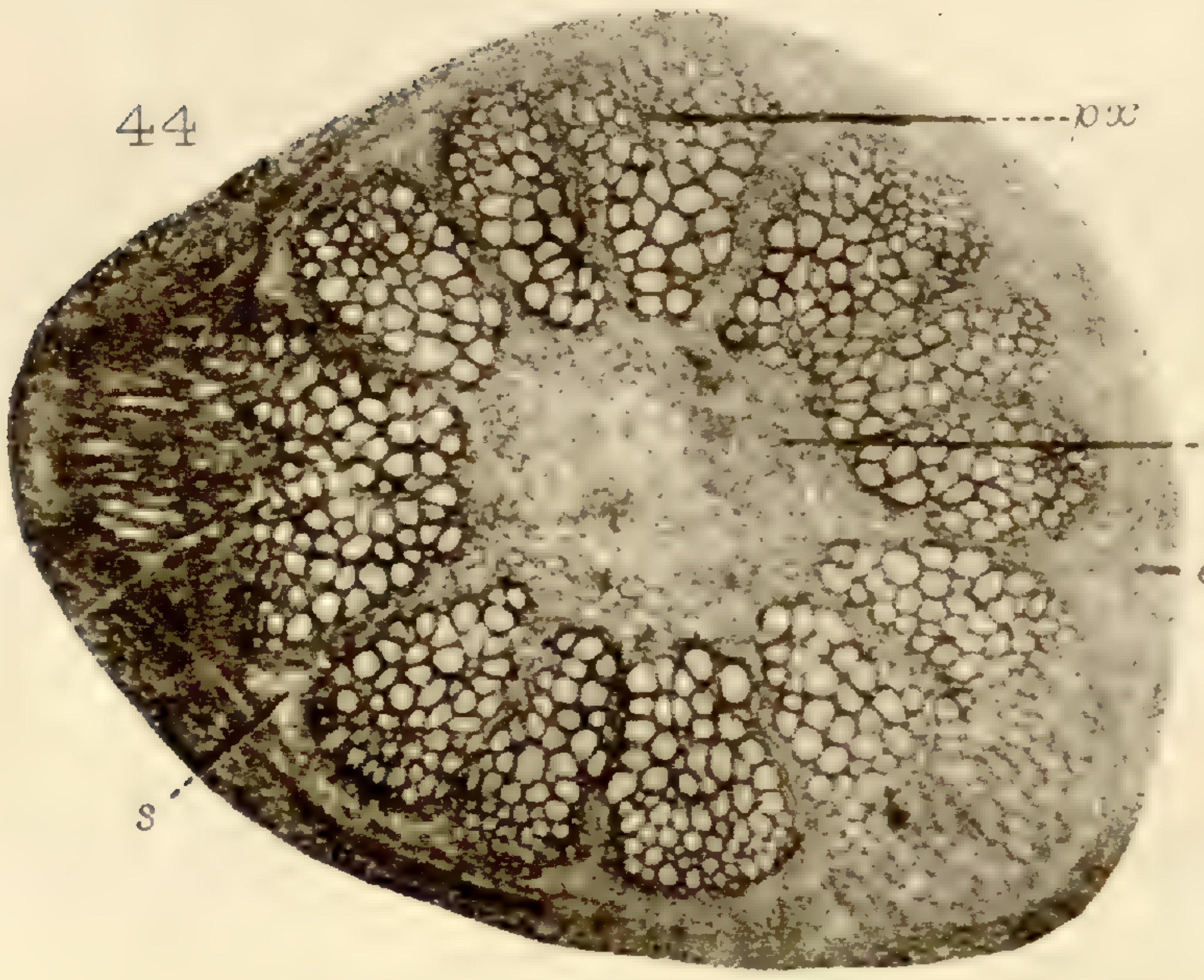
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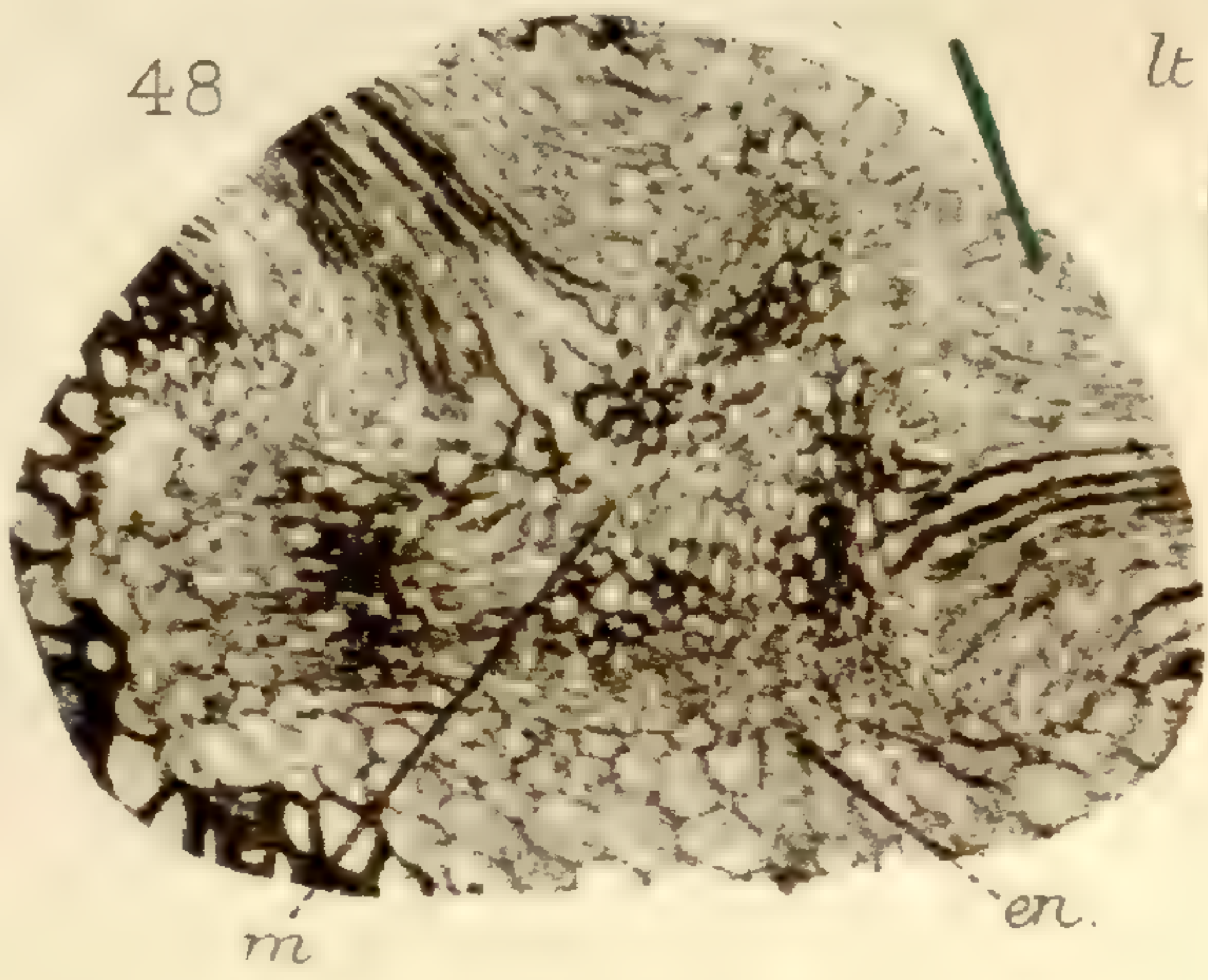
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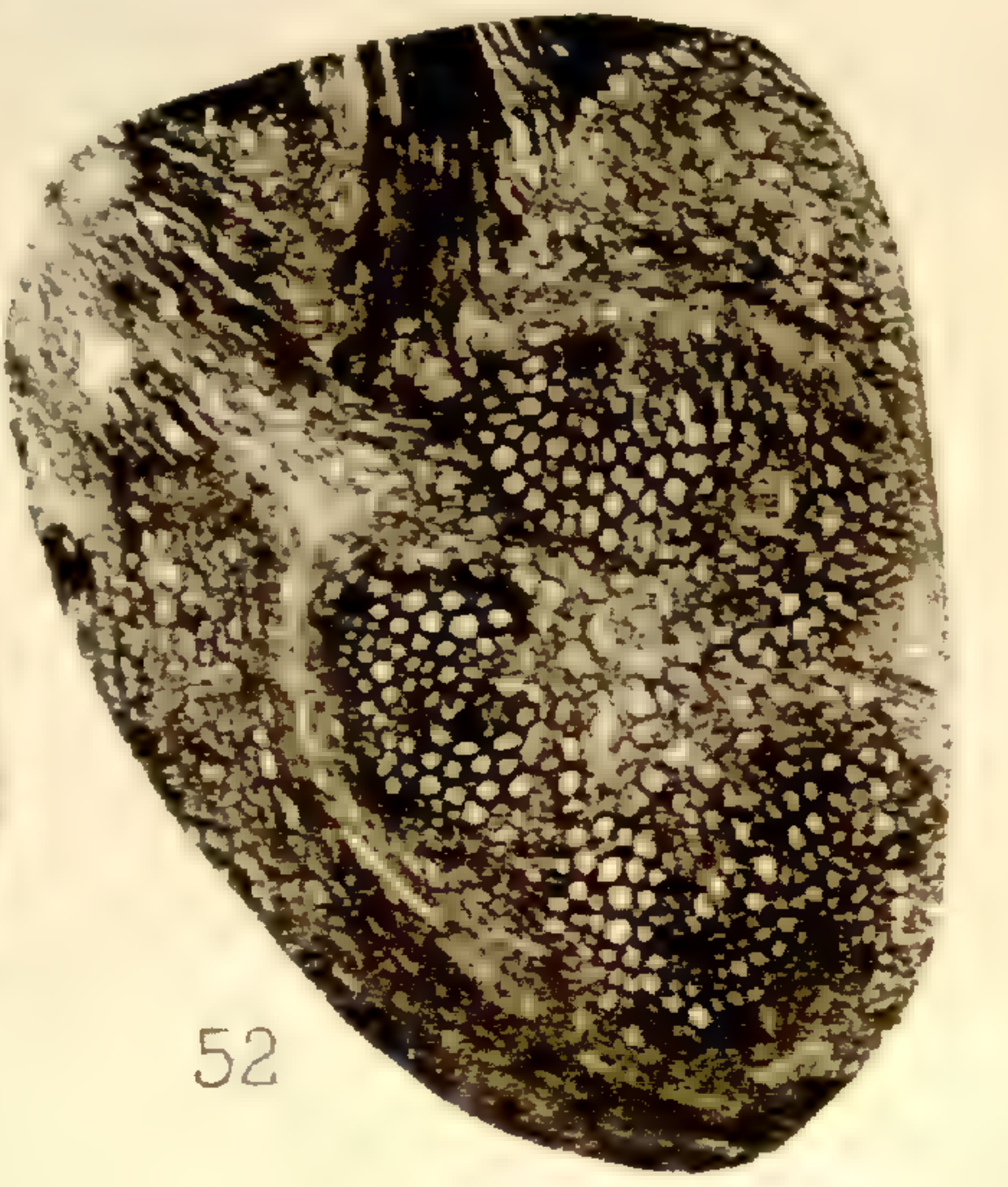
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2nd Ser. BOTANY.] [VOL. VI. PART 6.

THE
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OF
THE LINNEAN SOCIETY OF LONDON.

THE FLORA OF RAROTONGA, THE CHIEF ISLAND OF THE COOK GROUP.

BY
THOMAS F. CHEESEMAN, F.L.S., F.Z.S.,
CURATOR OF THE AUCKLAND MUSEUM, NEW ZEALAND.

NATURÆ
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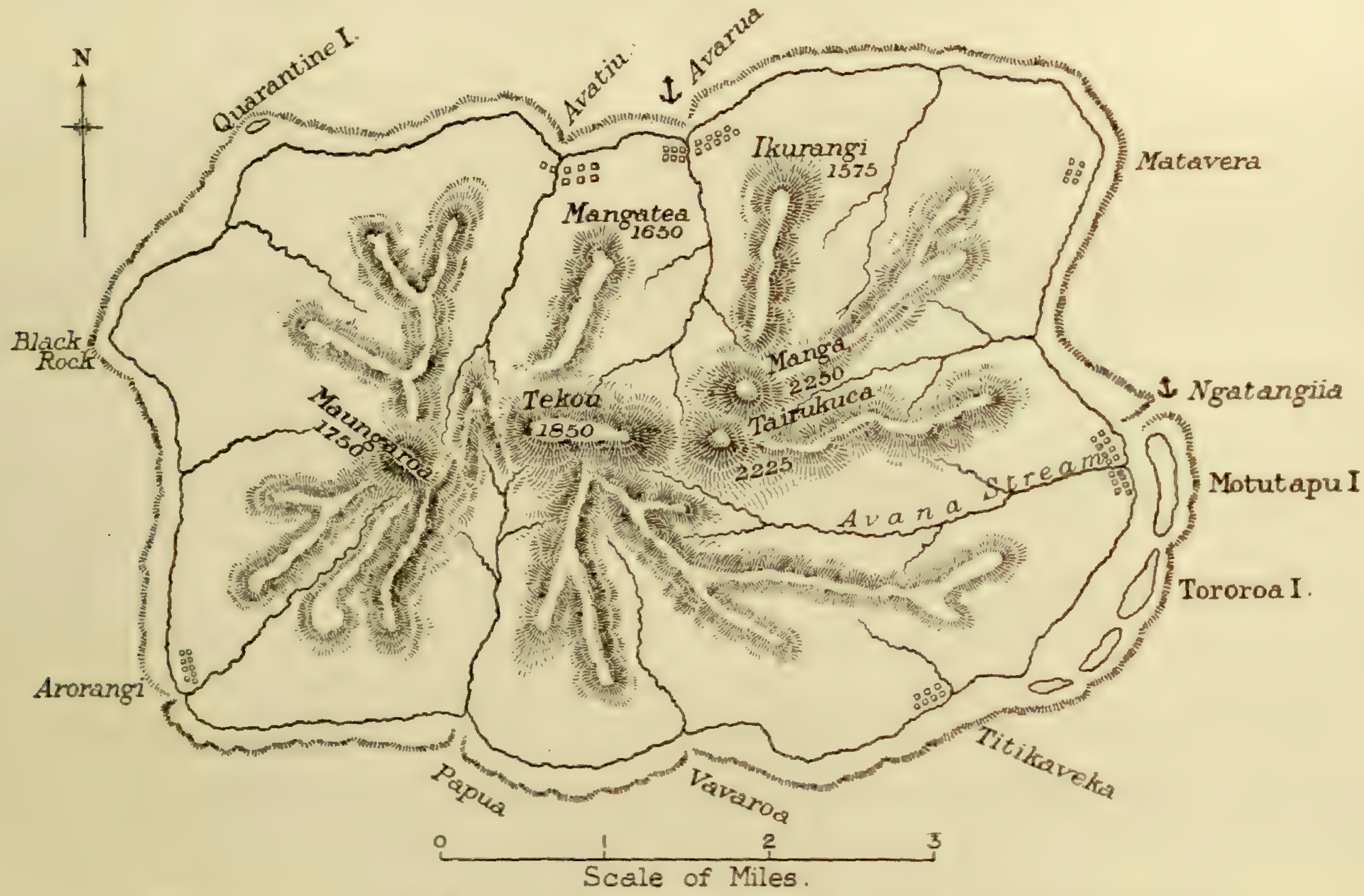
May 1903.

VI. *The Flora of Rarotonga, the chief Island of the Cook Group.* *By* THOMAS F. CHEESEMAN, *F.L.S., F.Z.S., Curator of the Auckland Museum, New Zealand.*

(Plates **31–35** and Map.)

Read 21st November, 1901.

LOOKING at a map of the Eastern Pacific, and scrutinizing the expanse of ocean, some 1300 miles across, which intervenes between the Tongan and Society Islands, there will be noticed a scattered group of eight or nine small islands known as the Cook Islands, by far the largest and most important of which is Rarotonga. Most of them were discovered by the illustrious navigator whose name they bear; but although Cook twice crossed the group from side to side he failed to sight Rarotonga. So far as I can ascertain, its discoverer was the notorious Capt. Goodenough, who landed thereon in 1821. Goodenough was one of those voyagers, not uncommon in the Pacific in the first half of the nineteenth century, who can be best described as half trader and half pirate. His unscrupulous conduct when trading on the northern coasts of New Zealand was for many years a matter of complaint among the Maoris, who knew him by the name of Kurunape, and his behaviour in Rarotonga was even more atrocious. By specious promises he decoyed a number of young girls on board his vessel, including some near relatives of the leading chiefs, and then suddenly took his departure. These girls he kept on board for some time, but eventually landed them at Aitutaki, the most northerly isle of the group, distant about 150 miles from Rarotonga. Goodenough did not make his discovery known, probably not being anxious to answer any inquiries respecting his doings while at the island; but shortly after his departure, Aitutaki was visited by the Rev. John Williams, so well known by his missionary voyages in the Pacific. Among the women landed by Goodenough was one called Tapairu, a chieftainess or "ariki" in her own right, and a cousin of Makea, the principal chief of Rarotonga. She became one of Williams's converts, and from her he learned the existence of Rarotonga. After two unsuccessful cruises, he at length found it, and landed thereon some time in 1823. Through the influence of Tapairu he obtained permission to leave two Tahitian teachers, who were shortly followed by two European missionaries. So successful were their labours, that when Williams revisited the island in 1827 he found that the whole population had embraced Christianity. He assisted in the preparation of a code of laws for the government of the island, and for many years missionary influence and teaching were paramount, although nominally the reins of power remained in the hands of the chiefs. European manners and customs were gradually adopted, English traders and others took up their residence on the island, and regular intercourse was opened with New Zealand. Eventually a British protectorate was established over both Rarotonga and the remainder of the Cook Group; followed, in October, 1900, by complete incorporation with the British Empire.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Avarua
Ikurangi
1575
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Mangatea
1650
Black Rock
Manga
2250
Ngatangiia
Tekou
1850
Maungaroa
1750
Tairukuca
2225
Avana Stream
Motutapu I.
Tororoa I.
Arorangi
Titikaveka
Papua
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0
1
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3
Scale of Miles.

Map of the Island of Rarotonga, Cook Group. Outline from the Admiralty Chart; interior from rough sketches by T. F. Cheeseman.

Like most of the islands of Eastern Polynesia, Rarotonga is of small size, being barely more than eight miles in greatest length, with a breadth of about six. It has a very diversified surface, and the high and bold peaks of the interior give it a most picturesque and romantic appearance. In shape it is roughly oblong, with the longer axis in the east and west direction, and the outline is singularly free from bays or other indentations. It is surrounded by a fringing coral-reef which in several places is only a short distance from the shore, although usually separated from it by a shallow lagoon perhaps a quarter of a mile in width. On the eastern side of the island the reef widens considerably, and has been slightly elevated, forming a chain of four little islets covered with cocoa-nut palms and other vegetation, and protecting a rather wider lagoon than usual. These little islands, or "motus" as they are called by the natives, are not only pretty in themselves, but are most interesting places to visit for anyone who wishes to understand how dry land may be gradually formed by the action of the wind and sea on a coral-reef. When a pile of loose coral blocks has been thrown up a little above the usual level of the waves it is quickly covered with vegetation and the nucleus of an island formed. Although the reef practically surrounds the island, several channels or openings lead through it which can be used as boat-landings, and three are sufficiently large to admit small vessels. One of these, called Ngatangiia, is near the chain of islets mentioned above; the two others are almost close together on the northern side of the island, the little villages of Avarua and Avatiu nestling round their shores. There is no harbour which ocean-going ships and steamers can enter, which must either anchor close to the reef, with everything in readiness for quick departure if the wind should set in on the shore, or lie off and on until their business is disposed of.

The actual shore of the island is everywhere low and is covered with vegetation to the verge of high-water mark, so that a few steps carry the traveller from the open beach into the recesses of a tropical forest. This strip of level land, varying from a quarter of a mile to a mile in width, surrounds the whole island. On it are situated the villages of the natives and their cultivations, also the few plantations occupied by Europeans. Near the beach the soil is light and sandy, but a little distance back it is much more fertile, and mainly composed of the débris of volcanic rocks washed from the hills of the interior. An excellent carriage-road runs parallel to the shore; and a drive round the island, which can easily be accomplished in four or five hours, is the readiest and most enjoyable way of making an acquaintance with the scenery and vegetation.

The whole centre of the island is a mass of rugged mountains, cut and worn by the denuding action of ages into fantastic peaks of very varied outline. The highest mountain, called Te Manga or Taitukura (or Tairukuca), has been variously estimated at from 2000 to 4000 ft. in height, but according to my measurements is not more than 2250 ft. The extreme peak is cone-shaped, and rises to an exceedingly sharp point, so that, when I ascended it, my party, numbering four in all, had barely room to comfortably seat themselves on the top. Owing to the steepness and narrowness of the cone and the small point of support, the view from the top is very similar to what is obtained from a balloon. The mountain next in height is called Tekou, or "the Mist," from its top being often shrouded in clouds. It is 1850 ft. high, and is remarkable for being perfectly flat-topped. Its northern face is little more than a straight wall of rock about a mile in length, so steep that it would be difficult of ascent but for the tropical vegetation which everywhere clothes its sides. But perhaps the most picturesque mountain is Ikurangi, which reaches a height of 1575 ft. Its western face forms a sheer precipice of over 500 ft. and almost overshadows the village of Avarua. It can be ascended on the eastern side, where, as in the case of Tekou, the climber makes use of the tropical vegetation to pull himself up places which otherwise it would not be easy to cross.

All through the island, the ridges which lead up to the higher peaks are remarkable for their sharpness and narrowness. In ascending Taitukura, it is necessary to pass along a ridge which in some places is certainly not more than a foot in width, and which on either side falls with a precipitous slope into a ravine hundreds of feet in depth. My native guides walked along this "knife-edge" unconcernedly; for myself, I must admit that I took to my hands and knees—a much safer, if more undignified, mode of progression.

The mountains are separated by narrow valleys, which gradually widen out towards the sea, but at their upper ends are pure mountain-gorges, often encumbered with huge blocks of stone which have rolled from the heights above. Pretty little streams of water flow down most of these; in fact the centre of the island is remarkably well watered. But, except after heavy rains, most of the streams disappear after reaching the belt of sandy and porous soil near the shore. The only stream which is absolutely permanent is one which has its source on the southern side of Tekou, and falls into the sea at Ngatangiia Harbour.

The geological structure of the island is purely volcanic. The sections exposed in the gorges, or on the precipitous sides of the mountains, show numerous lava-flows interbedded with conglomerates and ash-beds. No sign of a crater can be made out; but this is not surprising, for evidently the island has suffered so severely from denudation that only the skeleton of its former structure remains.

The climate is, on the whole, equable, the temperature rarely rising above 90° Fahr., or falling below 60°, although I believe that readings as low as 50° have been taken. The hottest time of the year is the period from November to April, which is also the rainy season. From May to October are the dry months, with usually a lower temperature, especially at night. But there is much variation, and heavy rains may occur at any time of the year. The total annual rainfall is about 90 inches, the monthly total ranging from $1\frac{1}{2}$ to 16 inches. Heavy falls of 2 or 3 inches or more in a few hours are not uncommon, and are usually accompanied with much thunder and lightning. Hurricanes are rare, and no serious one had occurred for many years previous to my visit. Fever is practically unknown; and, generally speaking, the climate must be considered remarkably healthy for a tropical locality.

Coming now to the vegetation, it can be roundly said that the whole island is covered with forest. Here and there a bare rocky face shows out on the sides of the mountains, and the slopes of a few hills are free from trees, but the total area of open land is quite insignificant. Even the cultivations of the natives—their orange-groves and coffee-plantations, their Banana- and Taro-patches—are either part and parcel of the forest or are sheltered and almost overshadowed by it. And with the exception of Ferns, which are everywhere plentiful, there are few low-growing herbaceous plants. Even most of the weeds are tall and robust, with woody stems reaching quite over one's head. And the forest has a recuperative power which, though common enough in a warm and moist tropical climate, is at first positively amazing to a stranger coming from cooler lands. No sooner has a clearing been abandoned than young trees everywhere spring up. In twelve months they have formed a jungle; in two years they are fifteen or twenty feet in height, and every vestige of former cultivation is gone. Speaking of the vegetation in general terms, there can be no doubt that the first impression conveyed to the mind is that of extreme luxuriance of growth and of richness and diversity of foliage. But there is no extraordinary display of floral beauty, and the trees, although many of them are handsome enough, are not remarkable either for size or symmetry of shape. Comparing the vegetation with that of New Zealand, with which a residence of many years has made me familiar, I can say that there is nothing in Rarotonga, nor probably in the whole of Polynesia, that can compare with a well-grown Kauri Pine (*Agathis australis*) or Totara (*Podocarpus Totara*), and no Rarotongan plant can offer a more brilliant mass of colour than the Pohutukawa (*Metrosideros tomentosa*). It is, as hinted above, the wealth of varied foliage and exuberant vigour of growth which constitute the chief attraction of the Rarotongan flora.

Examining the vegetation in detail, it will be seen that it is naturally divisible into three zones:—(1) the plants of the sea-shore; (2) those of the level strip of land which everywhere fringes the coast; and (3) those of the hilly and mountainous interior.

The first vegetation seen on the shore is usually one of three plants:—*Ipomœa biloba*, with its prostrate stems often 30 feet or more in length, broad fleshy leaves, and purplish flowers; *Triumfetta procumbens*; and *Thuarea sarmentosa*, a creeping grass with much of the habit of the buffalo-grass (*Stenotaphrum americanum*). *Heliotropium anomalum* and a few other species sometimes accompany them. All of these grow vigorously in pure coral sand, and in situations where they must be often drenched with salt spray. In open places they are followed by *Vigna retusa* and *Canavalia sericea*; but usually they are backed by shrubs or trees. On the northern and western coasts *Scævola Kœnigii* is the first shrubby plant to appear, usually forming a close-growing belt a few yards wide and from 4 to 8 feet high. On the eastern shore it is replaced by *Pandanus odoratissimus* or *Hibiscus tiliaceus*. Immediately behind these are *Casuarina equisetifolia*, *Hernandia peltata*, cocoa-nut palms, *Leucæna Forsteri*, *Morinda citrifolia*, *Barringtonia Butonica*, and a tall tree called Pukatea by the natives, but which, in the absence of flowers or fruit, I have been unable to determine. Of less common occurrence are *Calophyllum Inophyllum*, *Thespesia populnea*, *Cerbera Odollam*, and *Tournefortia argentea*. Growing under the shade of the trees are *Lepidium piscidium*, *Sophora tomentosa*, *Euphorbia Chamissonis*, *Wedelia aristata*, *Stenotaphrum subulatum*, *Polypodium Phymatodes*, *Nephrolepis acuta*, and *Asplenium Nidus*. In the few muddy places there is usually plenty of *Vitex trifolia*, with *Sesuvium Portulacastrum* lower down on the beach.

Leaving the vicinity of the shore, we next enter upon the fringe of almost level land which surrounds the whole island, curving round the foot of the hills and penetrating far up some of the valleys. At one time or another the whole of this has been under cultivation, but the portion at present tilled is small. The vegetation is thus more or less a second growth, and in places that have been recently cultivated is often largely composed of naturalized plants, including in the term not only introduced weeds, but also many economic or ornamental species now perfectly well established and spreading without man's assistance. The chief of these are the Papaw, Mango, Alligator-Pear, Custard-Apple, Orange, Lime, Guava, Grenadilla, Coffee, Cotton, Manioc, *Melia Azedarach*, *Bombax malabaricum*, &c. Of indigenous trees *Hibiscus tiliaceus* is by far the most abundant, often constituting the greater part of the vegetation; but the following are all plentiful:—*Hernandia peltata*, *Barringtonia Butonica*, *Aleurites moluccana*, *Cocos nucifera*, *Pandanus odoratissimus*, *Inocarpus edulis*, *Artocarpus incisa*, *Cananga odorata*, *Elæocarpus rarotongensis*, *Homalium acuminatum*, *Macaranga Harveyana*, *Pipturus velutinus*, and many others. The Polynesian Banyan (*Ficus prolixa*) is not common, but there are several fine specimens, one of which must extend over more than one acre of ground.

Of climbing plants the most conspicuous are *Colubrina asiatica*, *Canavalia ensiformis*, *Mucuna gigantea*, *Jasminum didymum*, and several species of *Ipomœa*. The undergrowth is largely composed of Ferns, *Asplenium Nidus* being particularly abundant. There are also a few shrubby plants, such as *Morinda citrifolia*, *Plectronia barbata*, *Guettarda speciosa*, and *Piper latifolium*.

Round the villages of the natives the following are invariably found :—*Erythrina indica*, *Cordia subcordata*, *Hibiscus Rosa-sinensis*, and *Acalypha tricolor*. The natives assert that they are truly indigenous, and it certainly appears that they were known on the island when Europeans first visited it. But I failed to find them in any situation where they had the appearance of being truly wild, and suspect that they were introduced by the natives themselves either from Tahiti or Samoa, possibly at such a remote period that all recollection of the event has been lost. At present they are associated with such plants as the Frangipani (*Plumeria*), Oleander (*Nerium*), and *Euphorbia* (*Poinsettia*) *pulcherrima*, which are known to be recent introductions.

The food-plants most commonly cultivated at the present time are the Banana, of which many varieties are grown ; the Bread-fruit ; the Taro (*Colocasia antiquorum*) ; the Kape (*Alocasia macrorhiza*) ; and several species of Yams (*Dioscorea*). The cultivations are usually patches of small size some distance apart, and they are by no means carefully attended to. Their neglected appearance and slovenly condition must be in strong contrast to that existing when the island first became known to Europeans, judging from the description given by Mr. Williams in his well-known book ‘Missionary Enterprise.’ He says :—“ The whole island was in a high state of cultivation, and I do not recollect having witnessed anything more beautiful than the scene presented to me, when standing on the side of one of the hills, and looking towards the sea-shore. In the first place, there are rows of superb chestnut-trees (*Inocarpus*) planted at equal distances, and stretching from the mountain's base to the sea, with a space between each row of about half a mile wide. This space is divided into small taro beds, which are dug four feet deep, and can be irrigated at pleasure. These average about half an acre each. The embankments round each bed are thrown up with a slope, leaving a flat surface on the top of six or eight feet in width. The lowest parts are planted with Taro (*Colocasia*) and the sides of the embankments with Kape or gigantic Taro (*Alocasia*), while on the top are planted at regular intervals small beautifully shaped bread-fruit trees. The pea-green leaves of the Taro, the extraordinary size of the Kape lining the sloping embankment, together with the stately bread-fruit trees on the top, present a contrast which produces the most pleasing effect.” At that time the island was densely populated, the inhabitants being estimated at about 30,000, or nearly ten times the present number. To feed so many people the cultivations must not only have been many times larger than at present but must also have required unremitting care and attention. A good idea of the former extent of the cultivations can be gathered from the number of abandoned Taro-beds, now mostly overgrown with trees, which stretch far up the valleys of the larger streams.

The mountainous interior of the island is seldom visited. The total absence of tracks, the steepness of the hills, and the dense jungle-like forest that everywhere covers the surface are perhaps sufficient reasons for this. The natives make periodical excursions up the valleys to gather the fruit of the mountain plantain, which grows abundantly near their sources, but they hardly ever go further. In fact, it is most unusual for either natives or Europeans to climb any of the mountains, and I was assured that the highest peak, Mount Taitukura, had not been ascended for at least eight years previous to my visit. And a very little inspection proves that the vegetation is in its primitive state, and has never been interfered with by man, save perhaps on some of the lower slopes.

Two trees stretch far up the valleys and ascend the hills to a height of at least 800 ft., usually composing the major portion of the forest. These are *Hibiscus tiliaceus* and *Aleurites moluccana*, the latter being perhaps the most abundant. Of other trees by far the most interesting is a new species of *Fitchia*, a very singular genus of Compositæ hitherto believed to be confined to the Society Islands, from whence three species are known. The present one, which I have described under the name of *F. speciosa*, is a very handsome small tree with fine bold glossy foliage and large orange-red heads. It is abundant on all the mountains, and above 500 ft. forms a considerable portion of the forest. Other interesting plants are *Homalium acuminatum*; *Elæocarpus rarotongensis*; *Xylosma gracile*; *Weinmannia rarotongensis*, allied to *W. samoensis*; *Pittosporum rarotongense*, with the habit of the Fijian *P. arborescens*; a new *Myrsine*; an *Alyxia* of the type of *A. stellata*, but differing in the fruit; and, lastly, a very distinct new species of *Sclerotheca*, a genus which, like *Fitchia*, had hitherto been supposed to be limited to Tahiti. Among previously well-known plants the following are abundant:—*Fagræa Berteriana*, *Terminalia Catappa*, *Alphitonia excelsa*, *Alstonia costata*, and *Leucosyke corymbulosa*. *Metrosideros villosa* (*M. polymorpha*, Gaud.), a species which is apparently plentiful in all the mountainous islands of the Pacific, from the Sandwich Islands on the north to the Kermadec Group in the south, is always found near the tops of the rocky peaks and along the crest of the ridges. It is often accompanied by *Ascarina lanceolata*, and more rarely by *Cypholophus macrocephalus* and *Homalanthus pedicellatus*.

Among shrubby plants perhaps the most plentiful are *Melastoma denticulatum* and *Mussænda frondosa*. *Osteomeles anthyllidifolia*, long supposed to be peculiar to the Sandwich Islands, but now known from several parts of Polynesia, is not uncommon. *Vaccinium cereum* occurs on all the higher peaks. Other noteworthy species are *Wikstrœmia viridiflora*; a handsome *Cyrtandra*, apparently undescribed; a new *Ixora*, allied to *I. fragrans*; and a new *Coprosma*.

In many places the chief undergrowth is formed by a species of *Freycinetia*. It has much of the appearance of the New Zealand *F. Banksii*, but is a smaller plant, with smaller and much less rigid leaves. Unfortunately neither flowers nor fruit could be obtained at the time of my visit. But of climbing plants by far the most prominent is *Entada scandens*, which sometimes covers acres of the forest with a dense canopy of green. Its enormous cable-like stems and huge pendent pods are sure to attract the notice of the most unobservant person. Other species deserving mention are *Vigna retusa*, *Cæsalpinia Bonduc*, and *Derris uliginosa*.

Orchids are not uncommon; but few of them were in flower at the time of my visit.

In moist shaded places *Phaius grandifolius* is often exceedingly plentiful. Its broad plaited leaves and tall spikes, often 4 to 6 feet high, with 12 to 15 large pale brownish-violet flowers, make it a very handsome plant. In many places I also noticed an undescribed *Habenaria*, with a tall naked stem furnished at the top with a rosette of spreading glossy leaves, from amongst which springs a slender spike of greenish flowers. It appears to be allied to the Fijian *H. superflua*.

At the sources of all the streams, and in damp shady places on the higher slopes of the mountains, the wild plantain (*Musa Fehi*) is most abundant, often forming dense groves, acres in extent, to the exclusion of all other vegetation. It is distinguished at a glance from the common banana by the dark-coloured, almost black, base of the stem, by the firm and more erect leaves, and especially by the erect bunches of red fruit. The natives make regular expeditions up the mountain valleys to collect the fruit, which is almost always cooked, seldom eaten raw. In bygone days, when the population of the island was many times larger than now, the groves of *Musa Fehi* were a most important resource in times of scarcity or when the cultivations of a tribe had been laid waste or pillaged by an enemy—a not unfrequent occurrence.

One of the most conspicuous features in the vegetation of the interior is the great abundance of Ferns. In most places they form the chief undergrowth; but on the summits of the mountains, and especially on the flat table-like top of Mount Tekou, they not only cover the ground with a dense tangled growth through which the explorer has to beat his way, but together with Mosses and Hepaticæ clothe every rock and tree-trunk with a mantle of green, and hang from the branches in long wisps and festoons. Out of a total flora of 233 truly indigenous plants the Ferns and Lycopods number no less than 72, not far from one-third of the entire flora, an exceeding large proportion. Tree-ferns, however, are remarkably rare; three species occur on the island, but one of them is apparently confined to a single locality, and the other two have a very restricted distribution and nowhere form a prominent part of the vegetation. I am unable to offer any satisfactory explanation of this peculiarity. From the humid nature of the climate, the number of sheltered ravines, and the general facies of the vegetation it would have been natural to surmise that tree-ferns would be abundant.

It is remarkable that the botany of Rarotonga has not been previously investigated, seeing that it is now 80 years since the discovery of the island, and that for the greater portion of that time Europeans have been living upon it. It cannot be said that it is difficult of access, when it is considered that for twenty years there has been regular steam communication with Auckland and Tahiti. So far as I can ascertain, the only scrap of information respecting the flora which has been published is a list of seven species collected by the Rev. W. Wyatt Gill, given by Mr. W. B. Hemsley in the Botany of the 'Challenger' Expedition (vol. i. 3, p. 116). The list appended to this paper is therefore the first attempt to draw up a systematic catalogue of the flora. It has been unavoidably prepared at a distance from large public herbaria and scientific libraries, and no doubt contains errors of omission and commission; but I trust that these will not be so numerous as to deprive it of value. It was my first intention to confine the list to indigenous species, relegating the naturalized plants to a supplementary catalogue;

but I soon found that it is now impossible to decide whether many species are native or introduced, and as similar catalogues which have been prepared for other portions of Polynesia include all well-established naturalized plants, I have followed the course thus indicated.

Altogether 334 species of vascular plants are enumerated in the catalogue. The orders most numerously represented are *Filices* with 67 species; *Gramineæ*, 25; *Leguminosæ*, 23; *Euphorbiaceæ*, 16; *Solanaceæ*, 11; *Compositæ*, *Rubiaceæ*, and *Malvaceæ*, 10 each; *Urticaceæ*, *Cyperaceæ*, and *Orchideæ*, 9 each. The following 18 species appear to be endemic:—

Xylosma gracile, Hemsl.
Pittosporum rarotongense, Hemsl.
Elæocarpus rarotongensis, Hemsl.
Weinmannia rarotongensis, Hemsl.
Homalium acuminatum, Cheesem.
Meryta pauciflora, Hemsl.
Ixora bracteata, Cheesem.
Coprosma lævigata, Cheesem.
Fitchia speciosa, Cheesem.
Sclerotheca viridiflora, Cheesem.
Myrsine Cheesemani, Hemsl. & Mez.
Alyxia elliptica, Cheesem.
Cyrtandra rarotongensis, Cheesem.
Habenaria amplifolia, Cheesem.
Freycinetia, sp. n.
Garnotia Cheesemanii, E. Hackel.
Chloris Cheesemanii, E. Hackel.
Nephrodium leucorhachis, Cheesem.

In the catalogue I have given a brief statement of the distribution of each species, so far as it can be done with the means at my command. For this part of the subject I have consulted Seemann's 'Flora Vitiensis,' Drake del Castillo's 'Flore de la Polynesie Française,' Hemsley's 'Flora of the Tongan Islands,' Burkill's 'Flora of Vavau'; also works of wider scope, as Hooker's 'Flora of British India' and Bentham's 'Flora Australiensis,' &c. Before summarizing the results, it seems advisable to eliminate from the total flora of 334 species all those which, so far as we can judge, have been introduced of late years through the direct or indirect agency of man. As already stated, this is no easy matter, and it is quite possible that some of the excluded plants may be truly native, although the balance of evidence appears to be against them. Altogether I have struck out 80 species on this ground, distinguished in the systematic catalogue by having an asterisk prefixed. A further deduction of 19 should also be made to include those species which in all probability have been introduced by the natives themselves prior to the arrival of Europeans, their names being as follows:—

Cananga odorata, Hook. f. & Thoms.
Hibiscus Rosa-sinensis, Linn.
Spondias dulcis, Forst.
Erythrina indica, Lam.
Eugenia malaccensis, Linn.
Lagenaria vulgaris, Seringe.
Gardenia taitensis, DC.
Cordia subcordata, Lam.
Ipomœa Batatas, Poir.
Piper methysticum, Forst.
Codiæum variegatum, Blume.
Acalypha tricolor, Seem.
Broussonetia papyrifera, Vent.
Artocarpus incisa, Linn.
Musa paradisiaca, Linn.
Dioscorea alata, Linn.
Dioscorea sativa, Linn.
Colocasia antiquorum, Schott.
Alocasia macrorhiza, Schott.

This will leave 235 species which without any doubt must be regarded as truly indigenous.

Examining the distribution of these 235 plants in detail, it appears that 167 are also found in Tahiti or some part of the Society Islands; while 129 occur in the Tongan Islands. 103 are common to both groups. These figures show that the flora is most nearly allied to that of Tahiti. A further proof of this is afforded by the presence of a species of *Fitchia* and another of *Sclerotheca*, genera hitherto believed to be peculiar to the Society Islands. At the same time, it should be mentioned that the preponderance of Tahitian species over Tongan is mainly due to the small number of Ferns recorded from Tonga, Hemsley's and Burkill's lists containing only 37 for the whole group as against 67 for Rarotonga. Most of the Rarotongan Ferns, in addition to being found in Tahiti, occur in Samoa, Fiji, and other parts of Western Polynesia; and if this is taken into account the preponderance of eastern plants is very slight indeed. It must be remembered that the vegetation of the Tongan, Cook, and Society Islands is only part of a Polynesian Flora which, in its main features, extends from the Solomon Islands to Easter Island and from Hawaii to Tongatabu.

My visit to Rarotonga extended over the months of May, June, and July—the time of the year best suited for investigating the flora. As I have travelled round the island, ascended all the mountains, and practically visited every portion of it, it may be concluded that my collections give a tolerably complete idea of the vegetation. There are, however, some half-dozen species which were not obtained in flower or fruit, and which consequently cannot be identified; and there are also a few species of Orchideæ and Scitamineæ of which only withered stems could be obtained at the time of my visit. Additions will doubtless be made, but I do not think that they will be very numerous.

Before passing on to the systematic catalogue, I wish to tender my most sincere thanks to the Bentham Trustees for contributing drawings of the new species. I have also to express my indebtedness to Sir W. T. Thiselton-Dyer, the Director of the Royal Botanic Gardens, Kew, for the kind assistance and encouragement he has given throughout, and to Mr. W. B. Hemsley for his unwearied kindness in examining and comparing my specimens and in superintending the preparation of the Plates. I have also to express my acknowledgments to Prof. E. Hackel, Dr. Stapf, Messrs. C. B. Clarke, C. H. Wright, and R. A. Rolfe, all of whom have rendered valuable aid.

CATALOGUE OF PHÆNOGAMIC PLANTS AND FERNS *observed during a Visit to the Island of Rarotonga, Cook Islands, May, June, and July,* 1899.

[Those species with an asterisk prefixed are probably naturalized.]

ANONACEÆ.

CANANGA ODORATA, Hook. f. et Thoms.—Native name *Moto-oi*. Common all round the island, but not ascending the hills. As in other parts of Polynesia, the fragrant flowers are used for scenting cocoa-nut oil. According to the chief Tarare, it was introduced by the natives themselves from Samoa, many generations ago.

From Philippines, Java, and Burma, southwards and eastwards, but often cultivated.

*ANONA SQUAMOSA, Linn.—Extensively cultivated by the natives and often naturalized near their villages. Introduced from Tahiti by the missionaries and early traders.

South America, but now largely cultivated throughout the tropics.

CRUCIFERÆ.

CARDAMINE SARMENTOSA, Forst.—Native name *Toa-toa*. Moist shady places, common by roadsides and in many of the native cultivations.

Plentiful in most of the Pacific Islands, from New Caledonia to the Marquesas.

*SENEBIERA PINNATIFIDA, DC. (*S. didyma*, Pers.).—Waste places and roadsides at Avarua, not common. Probably a recent introduction.

A weed in all warm countries.

LEPIDIUM PISCIDIUM, Forst.—Abundant along the shores, usually in shaded places. Not seen more than fifty yards from the beach.

Pacific Islands, from New Caledonia to Tahiti and the Sandwich Islands.

CAPPARIDACEÆ.

*CLEOME VISCOSA, Linn. (*Polanisia viscosa*, DC.).—Roadsides and waste places at Avarua, not seen elsewhere. No doubt a recent introduction.

Most warm countries.

CAPPARIS SPINOSA, Linn., var.—Coral rocks at the entrance to Ngatangiia Harbour. This appears to answer to *C. sandwichiana*, DC., a form which was first discovered in the Sandwich Islands by Menzies in Vancouver's voyage, and which was kept up as a distinct species by Asa Gray in the Botany of the United States Exploring Expedition. Mr. Hemsley, who has examined my specimens, considers that they are referable to *C. spinosa*, to which he reduces *C. sandwichiana*, DC., and *C. mariana*, Jacq., in Bot. Chall. Exped. i. 3, p. 120.

VIOLACEÆ.

Xylosma gracile, Hemsl., sp. nov.; "ab speciebus omnibus pacificis hactenus descriptis gracilitate ramulorum et foliis minoribus tenuioribusque differt.

"Arbor 15–25-pedalis, fere omnino glabra, dense ramosa, ramulis ultimis floriferis gracillimis. Folia distincte graciliterque petiolata, vix coriacea, lanceolata, ovato-lanceolata, elliptica vel interdum fere orbicularia, cum petiolo ½–2 poll. longa, præcipue supra medium crenato-dentata, crenis interdum subobsoletis, apice obtusa, basi cuneata vel rotundata, venis conspicue minuteque reticulatis. Flores (masculi tantum visi) pauci, in axillis foliorum fasciculati vel subracemosi, circiter 2 lin. diametro; pedicelli 1½–2 lin. longi. Sepala 5, elliptica vel orbicularia, ¾–1 lin. diametro, intus margineque pubescentia. Stamina numerosa, sepala vix superantia, glabra. Baccæ (maturæ non visæ) ovoideæ, vix 3 lin. longæ, læves, glabræ, sepalis ciliatis suffultæ, circiter 3-spermæ.

"A flowering specimen has long been in the Kew Herbarium. It is labelled: 'Soc'y Islands (H. dupl.).' It is supposed that it was collected by W. H. Harvey, who visited the Friendly and Fiji Islands in the Missionary Ship 'John Wesley,' in 1855. The specimen in question is from the Bentham Herbarium, the sheets of which were all stamped in 1867 with the date 1854—the date of presentation of the general collection, to which were added a good many specimens between 1854 and 1867, when it was amalgamated with the Hookerian Herbarium, purchased by Government."—*W. B. Hemsley.*

Native name *Rauriki.* An abundant tree on the hills of the interior, ascending to the tops of the highest peaks, 1800–2200 ft. alt.

PITTOSPORACEÆ.

Pittosporum rarotongense, Hemsl., sp. nov.; "species ex affinitate *P. arborescentis*, Rich., a qua differt foliis apiculatis, inflorescentiæ ramulis longioribus et floribus majoribus.

"Arbor 20–30-pedalis, omnino glabra, ramulis floriferis crassiusculis. *Folia* ad apices innovationum conferta, longe petiolata, coriacea, oblongo-lanceolata, pro maxima parte 3–6 poll. longa, apiculata, basi longe acuminata, margine cartilaginea, obscurissime crenulata, costa infra medium crassiuscula, venis ultimis tenuissimis minute reticulatis. Cymæ pauciramosæ, in axillis foliorum solitariæ, paucifloræ, 1–2 poll. longæ. Flores lutei, distincte pedicellati, circiter 5 lin. longi, erecti. Calyx 1½–2 lin. longus, inæqualiter 5-dentatus et unilateraliter a basi ruptus; dentes brevissimi, obtusi vel rotundati. Petala lineari-spathulata, obtusa, supra medium breviter coalita, apice recurva. Stamina inclusa. Ovarium clavatum, sparsissime puberulum, cum stylo brevi stamina fere æquans; placentæ 2, multiovulatæ."—*W. B. Hemsley.*

Native name *Kavakava.* Not uncommon on the hills all through the island. A glabrous highly aromatic tree 20–30 feet high, with oblong-lanceolate or obovate-

lanceolate leaves 4–5 in. long, and small yellowish flowers collected in terminal cymes. This species is so near to the Fijian and Tongan *P. arborescens*, Rich., and *P. rhytidocarpum*, A. Gray, that they may eventually have to be united.

PORTULACACEÆ.

*PORTULACA OLERACEA, Linn.—Plentiful throughout the lower portions of the island, particularly in sandy places and in many of the cultivations of the natives.

All warm countries.

PORTULACA LUTEA, Soland.—Coral rocks at the entrance to Ngatangiia Harbour, plentiful. Very different in appearance to *P. oleracea*, and certainly a distinct species. Much branched; branches erect or ascending, 1–1½ ft. high. Stem often as thick as the little finger, and with the branches dark red. Flowers large, yellow, nearly ½ in. diam., very fugacious. Solander's description, quoted in Seemann's 'Flora Vitiensis,' p. 9, agrees well with my specimens.

Society Islands.

GUTTIFERÆ.

CALOPHYLLUM INOPHYLLUM, Linn.—Native name *Tamanu*. Sparsely scattered all round the island, but nowhere abundant. In the olden times it was largely planted by the natives about their maraes, or religious meeting-places, and their idols were carved from its wood. Great numbers of the trees were consequently cut down by order of the first missionaries, hence its present scarcity. The wood was highly valued on account of its durability and canoes were frequently made from it.

India, Malay Archipelago, Australia, and the Pacific Islands generally.

MALVACEÆ.

*MALVASTRUM TRICUSPIDATUM, A. Gray.—A weed in the cultivation of the natives, of much too frequent occurrence.

Probably of American origin, but now widely distributed in the tropics.

*SIDA RHOMBIFOLIA, Linn.—Common everywhere in the cultivation of the natives, a most troublesome weed, often covering the ground to the exclusion of everything else. The "Broom" of the European settlers.

All warm climates.

*SIDA ACUTA, Burm. f. (*S. carpinifolia*, Linn.).—With the preceding, and almost equally abundant.

Generally distributed through the tropics.

*URENA LOBATA, Linn.—Roadsides and native cultivations; a troublesome weed.

All warm climates.

Hibiscus Rosa-sinensis, Linn.—Native name *Kaute*. This is a favourite plant with the natives, and is almost universally planted in their gardens. There are numerous varieties, differing in the colour of the petals, their duplication, and also in the variegation of the leaves. In all probability it was introduced by the natives themselves in their earlier migrations, but it is now said by them to be truly indigenous.

China, India, and the Malay Archipelago southwards through the Pacific Islands, but generally cultivated only.

*Hibiscus mutabilis, Linn.—Sparingly naturalized near the villages of the natives.

China, but widely cultivated in the tropics.

Hibiscus tiliaceus, Linn.—Native name *Au*. A most abundant tree all round the island, from sea-level to 800 ft. alt. It springs up readily on abandoned cultivations, soon covering them with an almost impenetrable scrub. Before the arrival of Europeans the bark was universally made use of for cordage, and it is still largely employed.

Generally distributed through the Pacific Islands and in most tropical countries.

Thespesia populnea, Soland.—Native name *Miro*. Lower portions of the island, but far from common. Wood valuable, formerly used for the handles of stone axes and other implements and for the seats of the chiefs. The bruised or charred leaves were frequently used as a dressing for wounds.

Throughout the Pacific Islands, and on the coasts of tropical Asia and Africa.

*Gossypium barbadense, Linn.—The cotton-plant was formerly largely cultivated and is spread in a naturalized state throughout the lower portions of the island, although now seldom planted.

Now common in all warm countries.

*Bombax malabaricum, DC.—Native name *Vavai*. Introduced by way of Tahiti about fifty years ago, and now plentifully naturalized.

India, Java, Sumatra.

TILIACEÆ.

Grewia Malococca, Linn.?—Native name *Auere*. Not uncommon in woods near Arorangi; slopes of Maungaroa; near Ngatangiia. Certainly a *Grewia*, but hardly answers to the description of *G. Malococca*.

Polynesian Islands, from Fiji to Tahiti.

Triumfetta procumbens, Forst.—Common on sandy beaches all round the island. Never seen more than a few yards inland.

Polynesian Islands, from New Caledonia to Tahiti, and northwards to the Malay Archipelago.

*TRIUMFETTA SEMITRILOBA, Jacq. ?—An abundant weed in the cultivations of the natives, by roadsides, &c. It is difficult to decide whether my specimens should be referred to this species or to *T. rhomboidea*, Jacq.

A common tropical weed.

ELÆOCARPUS RAROTONGENSIS, Hemsl. (Plate 31.)—Native name *Karaka.* Common throughout the island, from sea-level to the tops of the hills. A tree 25–35 ft. high, with a slender trunk and pale green foliage. Flowers whitish. Berries blue.

Endemic.

GERANIACEÆ.

OXALIS CORNICULATA, Linn.—Native name *Koki.* In shaded places, from sea-level to the tops of the mountains.

Cosmopolitan.

RUTACEÆ.

*CITRUS MEDICA, Linn., var. ACIDA, Brandis.—The Lime is largely cultivated, and is now copiously naturalized throughout the lower portions of the island.

Cultivated throughout the tropics.

*CITRUS AURANTIUM, Linn.—The Orange was introduced about 1830 from Tahiti, and is now plentiful in suitable places throughout the island.

Cultivated throughout the tropics.

MELIACEÆ.

*MELIA AZEDARACH, Linn.—Very plentiful in the lower portions of the island, forming large groves, and having all the appearance of a true native. I am assured, however, that it was introduced from Tahiti about forty years ago. It is the "Cedar" of the European settlers.

Persia, India, and China, and extensively cultivated elsewhere.

RHAMNACEÆ.

COLUBRINA ASIATICA, Brongn.—Common from sea-level to halfway up the hills.

Polynesian Islands, from New Caledonia to the Marquesas, and northwards through Australia to the Malay Archipelago and India.

ALPHITONIA EXCELSA, Reiss.—Scattered through the central and hilly parts of the island; not common.

Australia and New Caledonia to Tahiti and the Marquesas.

SAPINDACEÆ.

DODONÆA VISCOSA, Jacq.—Native name *Ake.* Rocky places on the mountains, apparently rare. Summit of Mangatea, 1200 ft.; ridges behind Tiriora.

All warm climates.

ANACARDIACEÆ.

*Mangifera indica, Linn.—Native name *Vi-papa*, or the foreign *Vi*. The Mango was introduced by the first missionaries and traders, and is now abundant through the whole of the lower portion of the island, spreading spontaneously without assistance from man.

India, and now generally cultivated throughout the tropics.

Spondias dulcis, Forst.—Native name *Vi*. Abundant throughout the island. The "wild Mango" of the European settlers.

Pacific Islands generally, and cultivated in many tropical countries.

LEGUMINOSÆ.

*Indigofera Anil, Linn.—A common weed in abandoned cultivations, waste places, &c., often forming dense thickets.

Cultivated or native in most warm climates.

Tephrosia purpurea, Pers.—Rocky slopes on the mountains, rare. Hills behind Arorangi; near Ngatangiia.

Pacific Islands, and common in many tropical countries.

Desmodium polycarpum, DC.—Open hill-sides in the interior of the island, plentiful.

Pacific Islands generally, and northwards to India, China, and Japan.

Abrus precatorius, Linn.—Scrambling over rocks and trees in the lower portions of the islands, but by no means plentiful.

All warm countries.

Erythrina indica, Lam.—Native name *Ngatae*. Extensively planted for ornament and shade near the villages of the natives, and often spreading spontaneously. The natives consider it to be indigenous, but it was probably introduced by them long before the advent of Europeans.

Pacific Islands, from Fiji to Tahiti and the Marquesas, and northwards through Australia and the Malay Archipelago to India.

Mucuna gigantea, DC.—Native name *Kaka-tea*. Common all round the lower portions of the island, hanging in festoons from the trees. Flowers greenish-yellow, pendulous, the peduncle often 3 feet in length. The specific name "*gigantea*" appears misplaced when the plant is seen by the side of the enormous masses of *Entada*.

Common in the Pacific Islands, and northwards through Australia to the Malay Archipelago and India.

Canavalia ensiformis, DC., var. turgida, Baker.—Everywhere in the lower part of the island, scrambling over trees and shrubs.

Most warm countries, excepting Australia.

CANAVALIA SERICEA, A. Gray.—Sandy and rocky places near the shore, common, especially on the southern and eastern sides of the island. Flowers dark red, forming a strong contrast to the purple flowers of the preceding species. A purely littoral plant, never seen many yards from the beach.

Fiji and Society Islands.

*PHASEOLUS ADENANTHUS, G. F. W. Mey.—Rich soils at the foot of the hills, not uncommon.

All warm climates.

VIGNA RETUSA, Walp.—Native name *Pohue*. Very common near the sea all round the island, and also plentiful in open places on the hills.

Generally distributed in the Pacific Islands, and a common littoral plant in the tropics of the Old World.

*DOLICHOS LABLAB, Linn.—Frequently seen in the lower parts of the island.

Most tropical countries.

DERRIS ULIGINOSA, Benth.?—Plentiful in hilly forests, scrambling over trees. I saw no flowers or fruit, and my identification must therefore not be regarded as certain. Mr. Hemsley, who has examined specimens, states that they either belong to *D. uliginosa* or a very closely allied species.

Tropics of the Old World.

*CAJANUS INDICUS, Spreng.—Plentifully naturalized in waste places, near the native villages, &c. Said to have been been introduced from Tahiti.

Almost all tropical countries.

INOCARPUS EDULIS, Forst.—Native name *Ii*, but the Tahitian name *Maupe* is also freely used. Low grounds, and by the sides of all the streams, plentiful. In the olden days often planted for the sake of its edible fruit, and many aged trees with historic associations are pointed out by the natives. The "Chestnut" of the European settlers.

Generally distributed through the Pacific Islands and extending northwards to the Malay Archipelago.

SOPHORA TOMENTOSA, Linn.—Not uncommon all round the shores of the island.

Most of the Pacific Islands, and generally diffused on tropical sea-coasts.

*CÆSALPINIA PULCHERRIMA, Sw.—Planted in the gardens of the natives for the sake of its showy flowers.

Native country doubtful; universally cultivated in the tropics.

CÆSALPINIA BONDUC, Roxb.—Native name *Tataramoa*. Hills near Ngatangiia, and elsewhere in the interior, apparently not common.

India and Malaya, Pacific Islands, West Indies.

*Cassia occidentalis, Linn.—Cultivations and waste places; an abundant and troublesome weed.

Now cosmopolitan in the tropics, but probably of American origin.

Entada scandens, Benth.—Native name *Kaka.* Most abundant in the interior of the island, climbing to the tops of the highest trees, and covering them with a widespreading canopy of green.

Cosmopolitan in the tropics.

*Mimosa pudica, Linn.—Very plentiful in abandoned cultivations, by roadsides, &c., and increasing fast.

Originally from tropical America, now widely spread through Polynesia and other warm regions.

Leucæna Forsteri, Benth.—Native name *Toromiro.* Abundant all round the island, usually near the sea.

Pacific Islands, from New Caledonia and Fiji to Tahiti.

*Leucæna glauca, Benth.—A few trees at the foot of Mount Maungaroa. Perhaps not indigenous, for I did not see it elsewhere.

Tropics of both hemispheres, but possibly native only of tropical America.

*Acacia Farnesiana, Willd.—Lower portions of the island, plentiful, particularly on the N.E. side.

Everywhere in the tropics, but often planted.

ROSACEÆ.

*Eriobotrya japonica, Lindl.—Introduced by the first missionaries, and now naturalized in many places.

The Loquat, now cultivated in most warm and many temperate climates.

Osteomeles anthyllidifolia, Lindl.—Tops of steep ridges in the centre of the island, 500–1800 ft. altitude, by no means common.

Sandwich Islands, Pitcairn Island.

SAXIFRAGACEÆ.

Weinmannia rarotongensis, Hemsl., sp. nov.; "species siccitate pallide virescens, foliis trifoliolatis, stipulis amplis, sepalis deciduis, seminibus piliferis.

"Arbor 30-pedalis vel ultra, ramulis floriferis gracillimis, novellis puberulis. Folia superiora breviter petiolata, trifoliolata, vel supremis interdum unifoliolata; foliola sessilia, vel intermedio petiolulato, coriacea, subinæqualia, anguste oblongo-lanceolata, 2–4 poll. longa, utrinque attenuata sed vix acuta, cito glabrescentia, supra nitida, subtus pallidiora, margine incrassata, apiculato-crenulata; stipulæ crassæ, rotundatæ, circiter 3 lin. diametro, cito deciduæ. Paniculæ terminales, sæpe 5-ramulosæ, folia paullo superantes, densifloræ. Flores albi, vix 2 lin. diametro, tetrameri; pedicelli graciles, circiter 1 lin. longi; bracteolæ nullæ vel minimæ et cito deciduæ. Sepala 4, ovata, obtusa vel rotundata, extus puberula. Petala 4, oblongo-ovata, obtusa vel rotundata, quam sepala longiora, circiter $\frac{1}{2}$ lin. longa. Stamina 8, disci squamis alternantia, glabra, $1\frac{1}{2}$–$1\frac{3}{4}$ lin. longa, filamentis filiformibus. Disci squamæ 8, minutæ, oblongo-quadratæ, liberæ. Ovarium puberulum, stigmate sessili. Capsula rubescentia, circiter 2 lin. longi, polysperma; semina oblonga, utrinque pilis paucis instructa."—*W. B. Hemsley.*

Hills in the interior of the island, plentiful. This has considerable affinity to several closely allied Polynesian species of *Weinmannia*, and its nearest allies are *W. vitiensis*, Seem., and *W. samoensis*, A. Gray. Possibly fuller materials may lead to the union of several of these forms under one species.

CRASSULACEÆ.

*BRYOPHYLLUM CALYCINUM, Salisb.—Naturalized in dry places at Avarua, Arorangi, and other localities.

Now spread through all tropical regions, but probably of African origin.

COMBRETACEÆ.

TERMINALIA CATAPPA, Linn.—Native name *Kauarika* or *Kaorika*. Not uncommon on low hills in the central parts of the island.

Throughout Polynesia, and extending northwards to Malaya and India.

MYRTACEÆ.

*LEPTOSPERMUM SCOPARIUM, Forst.—Several clumps on the south-eastern slopes of Mount Maungaroa, far from all cultivations. Doubtless introduced, but I could obtain no evidence of this.

Australia and New Zealand.

METROSIDEROS VILLOSA, Sm. (*M. polymorpha*, Gaud.).—Native name *Rata*. Abundant on all the hills, ascending to the tops of the highest peaks, alt. 2200 ft. There are two forms: one, which is much the more plentiful, has the young shoots and branches of the inflorescence silky or tomentose; the other has broader leaves and is nearly glabrous, the bark of the young branches being usually bright red.

Pacific Islands, as far south as the Kermadec Islands.

EUGENIA MALACCENSIS, Linn.—Native name *Kahika*. Plentiful throughout the island. The chief Tarare, to whom I am indebted for much information respecting the plants of Rarotonga, states that it is truly indigenous, and was largely cultivated and planted by the natives long before the advent of Europeans.

Cultivated in all tropical countries.

EUGENIA JAMBOSA, Linn.—Planted and naturalized in several localities. Called by the natives *Kahika-papa*, or the foreign *Kahika*.

South of China to Australia.

***PSIDIUM GUAJAVA**, Linn.—Plentifully naturalized, but has not spread so extensively as in Tahiti, where it has displaced the indigenous vegetation over large areas.

Now naturalized in most tropical countries, but originally from Mexico.

BARRINGTONIA BUTONICA, Forst.—Native name *Utu*. Common all round the island, particularly near the sea. Probably the finest tree in Rarotonga, attaining a height of 60 or 70 ft., with a wide-spreading crown of branches and massive trunk sometimes 6 ft. in diameter. As in other parts of Polynesia, the outer portion of the fruit is grated and used as a fish-poison.

Pacific Islands, from New Caledonia to the Paumotu Islands, northern shores of Australia to Malaya and India.

MELASTOMACEÆ.

MELASTOMA DENTICULATUM, Labill.—Native name *Kotaa*. A common shrub in open places on the hills.

Plentiful in most of the Pacific Islands, from New Caledonia to Tahiti.

ONAGRARIACEÆ.

***JUSSIÆA REPENS**, Linn.—Plentiful by the margin of a stream at Ngatangiia, but not seen elsewhere. Probably a recent importation.

Most warm countries.

***JUSSIÆA SUFFRUTICOSA**, Linn.—Abundant in Taro-swamps throughout the island, and presenting all the appearance of a true native. The chief Tarare informs me, however, that it was introduced from Tahiti about 25 years ago by a half-caste called "Jim" Harrison, and that the natives gave it its present name "*Tiemu*" from his name "Jim."

Widely distributed in warm countries.

SAMYDACEÆ.

HOMALIUM ACUMINATUM, Cheesem., sp. nov.; arbor 15–40-pedalis, inflorescentia excepta glaberrima, trunco 1–3 poll. diametro; rami divaricati. Folia alterna, 3–7 poll. longa, late ovata vel ovato-oblonga vel ovato-lanceolata, abrupte acuminata, basi rotundata vel cuneata, subcoriacea vel membranacea, irregulariter sinuato-serrata, nervis utrinque distinctis, venulis reticulatis; petioli $\frac{1}{2}$–1 poll. longi. Racemi axillares, elongati, 4–8 poll. longi, simplices vel laxe ramosi; rhachis gracilis dense pubescens; pedicelli $\frac{1}{8}$–$\frac{1}{6}$ poll. longi. Flores virides, $\frac{1}{3}$ poll. longi, sericeo-villosi. Calycis lobi sæpe 8, lineares. Petala 8, anguste lineari-oblonga. Stamina ad quodque petalum 3 (rarissime 2), fasciculata. Styli 4–5, villosi.

Common all through the island, from sea-level to quite 1000 ft. The lower branches are often pendulous, and present a very graceful appearance when loaded with the abundant racemes of tassel-like flowers. Wood red, durable, used for making canoes, &c. Native name *Moto.* Closely allied to the Fijian and Tongan *H. vitiense*, Benth., but the leaves are larger and acuminate, inflorescence much laxer, and the flowers are distinctly pedicellate.

PASSIFLORACEÆ.

*PASSIFLORA QUADRANGULARIS, Linn.—The Grenadilla was introduced from Tahiti about the year 1850, and is now naturalized in many places, presenting all the appearance of a true native.

Tropical America.

*CARICA PAPAYA, Linn.—Native name *Ninita.* Extremely abundant, not only in the lowlands, but stretching far back into the hills. Introduced by the first missionaries about 60 years ago, and has become so thoroughly established that if a clearing is made in the forest the first vegetation to spring up is often largely composed of Papaw trees.

Tropical America.

CUCURBITACEÆ.

LAGENARIA VULGARIS, Seringe.—Native name *Ue.* Cultivated by the natives from time immemorial, but not often seen at the present time.

Cultivated in most warm countries.

LUFFA CYLINDRICA, Roem., var. INSULARUM, Cogn.—Native name *Motine.* Not uncommon in the lower portions of the island, climbing trees.

Throughout Polynesia, also in Australia and the Malay Archipelago.

*CUCUMIS MELO, Linn.—The Melon, in several of its forms, is frequently cultivated, and often seen in a semi-naturalized condition.

Plentiful in all warm countries.

*CITRULLUS VULGARIS, Schrad.—The Water-Melon. The same remarks apply.

FICOIDACEÆ.

SESUVIUM PORTULACASTRUM, Linn.—Sandy flats along the edge of Ngatangiia Harbour, common, but not seen elsewhere.

Shores of most warm countries.

UMBELLIFERÆ.

HYDROCOTYLE ASIATICA, Linn.—Common. Attains a large size in moist shaded places, in the lower portions of the island. A smaller form occurs on dry hills.

Throughout Polynesia, and plentiful in most warm countries.

*APIUM LEPTOPHYLLUM, F. Muell.—Waste places about the native villages, and along the sides of roads; probably a recent immigrant.

Most warm countries.

ARALIACEÆ.

MERYTA PAUCIFLORA, Hemsl., sp. nov.; "*M. lanceolatæ*, Forst., proxima, differt foliis breviter petiolatis obscure lateque crenatis, inflorescentia feminea brevi spiciformi.

"Arbor 10–15-pedalis, trunco simplice foliorum coma ampla coronato, rarius a basi ramoso. Folia breviter sed distincte petiolata, coriacea, glabra, superiora oblanceolata, 12–15 poll. longa, basi cuneata, apice acuta, margine leviter incrassata sæpe præsertim supra medium obscure remoteque crenata, costa crassa, venis primariis lateralibus paucis distantibus, venis ultimis tenuibus minute reticulatis. Spicæ femineæ axillares, cum pedunculo brevi, 1½–2 poll. longæ, paucifloræ. Flores sessiles, conferti, bracteolis latis suffulti. Perianthium simplex, calyciforme, carnosum, sæpissime 8-lobum; lobi sæpe inæquales, dentiformes, sæpe deltoidei, persistentes, erecti vel sub stylos oppositos inflexi. Ovarium sæpissime 8-loculare, stylis brevissimis arcte recurvis persistentibus. Fructus deest."—*W. B. Hemsley.*

Native name *Kakaratua*. Dry slopes towards the interior of the island, not uncommon. This is readily distinguished from its nearest allies by the short, spicate female inflorescence.

RUBIACEÆ.

OLDENLANDIA FŒTIDA, Forst.—Native name *Maire*. Bare rocky places on the mountains, alt. 800–2000 ft., Mangatea, Ikurangi, &c. This appears to have narrower leaves than Forster's plant, and may prove distinct.

Tongan Islands, Savage and Palmerston Islands.

MUSSÆNDA FRONDOSA, Linn.—Native name *Kotuku*. A common shrub on dry hills all round the island. The native name is from a fancied resemblance of the enlarged white calyx-lobe to the white plumes of the "*Kotuku*" or Heron (*Ardea sacra*).

Throughout the Pacific Islands, and northwards to Malaya, India, and China.

GARDENIA TAITENSIS, DC.—Native name *Tiare*. The native women are exceedingly fond of adorning their hair with the large white fragrant flowers of this plant, and it is universally planted about their houses. The natives consider it to be indigenous, but I did not see it in any situation where it had the appearance of being wild, and suspect that it was introduced by them from Tahiti long before the advent of Europeans.

Stretches across Polynesia, from Fiji to the Marquesas, but often planted.

GUETTARDA SPECIOSA, Linn.—Native name *Ano*. Common all round the island, and forming a large part of the undergrowth in the forest near the sea, but not ascending the hills to any considerable height.

Shores of most warm countries, and extremely plentiful throughout the Pacific.

Plectronia barbata, Benth. & Hook. f.—Native name *Matira*. From sea-level to the tops of the mountains, plentiful.

Pacific Islands; Fiji and Tonga eastwards to the Society Islands and the Marquesas.

Ixora bracteata, Cheesem., sp. nov.—Frutex 8–15-pedalis, undique glaber, ramulis gracilibus. Folia 2–5 poll. longa, ovato-oblonga vel elliptico-oblonga, obtusa vel subacuta, basi rotundata, subcoriacea, margine integra, venis conspicuis reticulatis; petioli breves, $\frac{1}{4}$–$\frac{1}{3}$ poll. longi. Inflorescentia terminalis ad cymulas 3–5-floras reducta; cymuli intra bracteas duas amplas orbiculatas vel transversim ellipticas occlusi. Flores sessiles, albi, dimorphi, aliis longioribus tubo corollæ gracili 1–1$\frac{1}{2}$ poll. longo, aliis brevioribus tubo corollæ crasso $\frac{3}{4}$ poll. longo. Calyx parvus, puberulus, obscure 4-dentatus. Corollæ lobi 4, patentes, conspicue contorti. Stamina 4, ori corollæ inserta, filamentis latis brevissimis; antheræ lanceolatæ, acuminatæ, exsertæ. Stylus elongatus, gracillimus, corollam superans; stigma bilobum, lobis crassiusculis. Fructus $\frac{1}{3}$ poll. longus, oblongus, rubicundus, parum succosus.

Hills of the interior, not uncommon. Native name *Itoa*.

This belongs to Asa Gray's section *Phylleilema*, characterized by the flowers being collected in fascicles of 3 or 4 within two opposite floral leaves or bracts. It is evidently closely allied to *Ixora fragrans*, Asa Gray.

*Coffea arabica, Linn.—The Coffee-plant was introduced many years ago, and has been extensively planted. It spontaneously reproduces itself from seed, and is now common in most parts of the island.

South-western Asia.

Morinda citrifolia, Linn.—Native name *Nono*. Abundant, especially near the sea. The fruit is often eaten by the natives.

Very plentiful in the Pacific Islands; also found on the shores of tropical Australia, Asia, and Africa.

Geophila reniformis, D. Don.—Native name *Kapu-kapu*. Common in moist shaded places and by the side of streams.

Most tropical countries.

Coprosma lævigata, Cheesem., sp. nov.—Frutex 5–12-pedalis, glaberrimus, ramosus, cortice lævi griseo; ramuli graciles, foliosi. Folia 1–3 poll. longa, ovata vel ovato-oblonga vel elliptico-oblonga, acuta vel breviter acuminata, membranacea, in petiolum $\frac{1}{2}$–$\frac{3}{4}$ poll. longum attenuata, supra lucidiuscula, subtus pallidiora, venis primariis utrinque sat conspicuis, venulis reticulatis. Stipulæ late ovatæ, ciliatæ. Pedunculi graciles, petiolo breviores, 3–5-flori vel rarissime 5–7-flori. Flores minuti, $\frac{1}{10}$–$\frac{1}{8}$ poll. longi, sessiles vel brevissime pedicellati. Corolla ♂ late cam-

panulata, usque ad medium 4-fida; stamina 4. Corolla ♀ infundibularis, 3–4-fida; styli 2, longi, graciles, pubescentes. Fructus ignotus.

Hilly parts of the island, plentiful. Native name *Angi.*

Very closely allied to the Kermadec Islands *C. acutifolia*, Hook. f., but smaller and more densely branched, with shorter and broader leaves, shorter unbranched peduncles, and much fewer and smaller flowers. It is slightly fragrant when bruised or drying, so that the natives are fond of weaving head-dresses from the young branches.

COMPOSITÆ.

*VERNONIA CINEREA, Linn.—A common weed in cultivations, by roadsides, &c.

Abundant in the tropics of the Old World.

ADENOSTEMMA VISCOSUM, Forst.—In cultivations and in open places in the forest; not rare.

Most warm countries, and extending northwards as far as Japan.

AGERATUM CONYZOIDES, Linn.—A most troublesome and aggressive weed, spread all over the island.

All warm countries.

FITCHIA SPECIOSA, Cheesem., sp. nov. (Plate **32.**)—Arbor parva, 8–25-pedalis, omnino glaberrima, trunco gracili 6–12 poll. diametro; rami crassiusculi versus apices foliosi. Folia magna, opposita; petiolus gracilis, 2–5 poll. longus; lamina 4–8 poll. longa, 1½–3½ poll. lata, oblongo-ovata vel oblongo-lanceolata, acuta vel acuminata, basi cuneatim angustata, membranacea, margine integra vel obscure irregulariterque crenulata, nervis primariis a costa angulo acuto abeuntibus, venulis reticulatis. Capitula ad apices ramorum solitaria, læte aurantiaca, magna, 3–4 poll. diametro, pedunculata, nutantia; pedunculi crassi, decurvi, 2 poll. longi, basi 1–3 bracteis linearibus instructi. Involucrum latum, bracteis intimis ovato-lanceolatis vel linearibus acuminatis, exterioribus brevioribus ovatis vel ovato-oblongis. Corollæ ligulatæ, profunde 5-partitæ, segmentis angustis apice filiformibus. Achænia (matura non visa) lineari-oblonga, villosa, marginibus in setas duas longas villosas productis.

Central and hilly portions of the island, often forming the greater part of the forest at elevations of over 500 ft., and reaching the tops of the highest peaks, at 2250 ft. Native name *Nei-nei.* It varies greatly in size: when growing in the sheltered valleys it often attains a height of 25 ft.; but on the exposed ridges or on the summits of the hills it is much dwarfed, and often not more than 5–8 ft. The roots are frequently aerial, somewhat after the fashion of *Pandanus*, leaving the stem 2 or 3 ft. above the ground, and repeatedly forking before entering it. In the flowering-season the natives make numerous expeditions to the hills in order to collect the honey from the flowers, which is secreted in large quantities. As a species, *F. speciosa* differs from the Tahitian

F. nutans in the longer and narrower leaves, which are not cordate at the base, in the scales of the involucre not being rounded, and in the longer awns of the achenes. *F. Temariiana*, also from Tahiti, is perhaps more nearly allied, but the leaves are smaller, and the heads are frequently 2 or 3 on a common peduncle, whereas they are always solitary in *F. speciosa*. For some pertinent remarks on the systematic position of *Fitchia*, reference should be made to Hemsley's "Botany of the Voyage of the 'Challenger'" (i., Introduction, p. 20).

The discovery of this fine species still further commemorates the services rendered to botany by the accomplished British artists, WALTER HOOD FITCH and JOHN NUGENT FITCH, uncle and nephew. [I am glad to see the name of the latter associated with the Plates illustrating this paper.]

SIEGESBECKIA ORIENTALIS, Linn.—Cultivations and waste places, not very common.

A weed in all warm countries.

ECLIPTA ERECTA, Linn.—Taro-swamps and wet places generally, not uncommon.

All warm regions.

WEDELIA ARISTATA, Less.—Southern and eastern shores of the island, not uncommon.

Tropics of the Old World.

*TITHONIA TAGETIFLORA, Desf.—Largely planted in the gardens of the natives, and has established itself in several localities.

Mexico.

BIDENS PILOSA, Linn.—Abundant on dry hills, and a frequent weed in the cultivations of the natives.

All warm countries.

SONCHUS OLERACEUS, Linn.—Not uncommon, and probably indigenous.

Almost cosmopolitan.

GOODENIACEÆ.

SCÆVOLA KŒNIGII, Vahl.—Forms a fringe around the greater part of the island, just above high-water mark, but never extends more than a few yards inland.

Abundant throughout the Pacific Islands, also on the shores of tropical Asia and Australia.

CAMPANULACEÆ.

SCLEROTHECA VIRIDIFLORA, Cheesem., sp. nov. (Plate **33**.)—Frutex 4–6-pedalis, omnino glaberrimus, succo lacteo copioso. Ramuli validi, transversim cicatrosi, basi nudi, versus apices foliosi. Folia alterna, 3–9 poll. longa, lineari-oblonga vel oblongo-lanceolata, acuta vel acuminata, in petiolum ½–1 poll. longum attenuata, argute serrata, membranacea, venis primariis utrinque sat conspicuis. Flores virides in axillis foliorum solitarii, pedunculo gracili ad 1 poll. longo, bracteis 2 linearibus. Calycis tubus ovario adnatus, turbinatus, lobis 5 anguste linearibus. Corolla 1–1¼ poll. longa, tubo dorso fere ad basin fisso, lobis 5 subæqualibus oblongis acutis. Staminum tubus arcuatus, a corolla liber; antheræ 2 minores vertice penicillatæ, 3 majores vertice ciliatæ. Stylus exsertus; stigma breviter 2-fidum. Fructus ignotus.

Slopes of Mount Taitukura, 1500–2200 ft., plentiful, but not seen elsewhere. The corolla is split to the base at the back, and the three larger anthers are ciliate at the apex—characters which depart from the description of the genus given in Bentham and Hooker's 'Genera Plantarum.'

Sclerotheca sp.?—Mount Mangatea, alt. 1000–1500 ft., rare. Flowers and fruit not seen, and the identification is consequently uncertain. The leaves are much larger and broader than in the preceding species.

VACCINIACEÆ.

Vaccinium cereum, Forst.—Summits of most of the higher hills, alt. 800–2200 ft. The fruit is eaten by the natives.

Society Islands and the Marquesas.

MYRSINACEÆ.

Myrsine Cheesemani, Hemsl. ex Mez, Myrsinaceæ, p. 371. (*Rapanea Cheesemani*, Mez, l. c.) (Plate **34**.)

Not uncommon on the higher mountains, Ikurangi, Mangatea, Taitukura, &c., alt. 1200–1800 ft.

SAPOTACEÆ.

Bassia, sp.—Hill-sides at Tiriora, rare, and not seen elsewhere. A tree 20–40 ft. high, with large glossy obovate or oblong-obovate leaves 9 in. long. Flowers not seen. Berry 1½ in. long, obovoid. Seeds 2, long and narrow. Embryo large, occupying the whole of the seed except a thin plate of albumen on each side. Cotyledons oblong, large; radicle minute, inferior.

OLEACEÆ.

Jasminum didymum, Forst.—Native name *Aketa*. Widely spread through the island, from sea-level to a considerable elevation on the hills. The tough twining stems are often used for tying up fences.

New Caledonia and Fiji to Tahiti, and from North Australia to Java.

APOCYNACEÆ.

ALYXIA ELLIPTICA, Cheesem., sp. nov.—Frutex 6–15-pedalis, undique glaber, ramosissimus, succo lacteo; ramuli erecti, ad nodos incrassati. Folia opposita vel ternatim verticillata, 1½–2 poll. longa, ovata vel elliptico-oblonga, obtusa vel obtuse acuminata, breviter petiolata, coriacea, venis lateralibus centrali perpendicularibus, margine plana. Flores albi, ½ poll. longi, pauci (2–4) in fasciculos parvos terminales et axillares dispositi, pedicellis gracilibus quam flores brevioribus. Calyx alte 5-fidus, segmentis acutis. Corolla matura non visa. Drupæ 2 vel abortu solitariæ, stipitatæ, ½ poll. longæ, oblongæ, monospermæ, succosæ.

Abundant on rocky places on the hills, often forming extensive thickets. Native name *Maire-rakau*. Closely allied to *A. stellata*, Rœm. & Schult.

CERBERA ODOLLAM, Gærtn.—Native name *Reva* or *Ava*. Lower portions of the island, usually not far from the sea, not common. The milky juice was formerly used as a liniment in severe cases of rheumatism.

Pacific Islands, shores of North Australia, India, and China.

*VINCA ROSEA, Linn.—Planted in the gardens of the first missionaries and traders, and now plentifully naturalized near all the villages.

Originally from America, but now widely spread in most tropical countries.

*PLUMERIA ALBA, Linn.—The Frangipani. Also introduced by the early missionaries. It has become a great favourite with the natives, and is everywhere seen in their gardens.

Tropical America, but now largely planted for ornament in hot countries.

ALSTONIA COSTATA, R. Br.—Hills of the interior, not uncommon above 250 ft. altitude. A very handsome tree 15 to 25 ft. high, with copious milky juice. Leaves remarkably glossy. Flowers white or yellow, in large spreading panicles.

Society Islands.

*NERIUM OLEANDER, Linn.—Largely planted by the natives for ornament, and naturalized in several places.

South Europe and Asia Minor to Persia, but now cultivated in all warm countries.

ASCLEPIADACEÆ.

*ASCLEPIAS CURASSAVICA, Linn.—An abundant weed in the cultivations of the natives. Now common in most warm countries, originally from tropical America.

LOGANIACEÆ.

Geniostoma rupestre, Forst. ?—Southern slopes of Maungaroa, not seen elsewhere. I do not feel quite sure that this species is correctly identified.

New Caledonia and Fiji to Tahiti.

Fagræa Berteriana, A. Gray.—Native name *Fua.* Plentiful on the hills of the interior, ascending to the tops of the highest peaks. Sometimes planted for ornament near the native villages. The flowers are deliciously fragrant, and are collected and strung into necklaces by the natives, retaining some of their fragrance long after they are dry. The wood is said to be exceedingly durable, and was used for all classes of carved work, and especially for the elaborately carved handles of the ceremonial axes reserved for the use of the chiefs.

New Caledonia and Fiji to Tahiti and the Marquesas.

BORAGINACEÆ.

Cordia subcordata, Lam.—Native name *Tou.* Plentiful near the villages of the natives, but perhaps planted only. The chief Tarare informed me that it was brought to Rarotonga by the natives themselves, long before the advent of Europeans.

Throughout the Pacific Islands, and plentiful in the warm regions of the Old World.

Tournefortia argentea, Linn. f.—Native name *Tauhinu.* Eastern shores of the island, a few clumps at Matavera and Ngatangiia, just above high-water mark.

Abundant throughout the Pacific Islands, and on the coasts of North Australia, Malaya, India, and Mauritius.

Heliotropium anomalum, Hook. & Arn.—Plentiful on sandy shores just above high-water mark. Leaves much larger than described by Drake del Castillo.

Society Islands, Paumotu Group, Sandwich Islands.

CONVOLVULACEÆ.

*Argyreia tiliæfolia, Wight.—Scrambling over walls and rocks at Matavera, on the eastern side of the island, probably introduced.

India and Malaya to the Philippines, but often cultivated in warm climates

Ipomœa grandiflora, Lam.—Common near the sea, all round the island.

Tropics of the Old World, abundant.

Ipomœa peltata, Choisy.—Woods near the sea, abundant all round the island, climbing to the tops of the trees.

Fiji to Tahiti, North Australia, Malaya. Mauritius.

IPOMŒA DENTICULATA, Choisy.—Native name *Pipa.* Common in open places, dry hill-sides, &c.

New Hebrides and Fiji to Tahiti, Australia, India, Malaya.

IPOMŒA BILOBA, Forst.—Native name *Pohue.* Everywhere on sandy shores, most abundant.

Tropical sea-shores of both hemispheres.

IPOMŒA BATATAS, Poir.—Native name *Kumara.* Cultivated by the natives from time immemorial. According to the chief Tarare, the kinds cultivated before the arrival of Europeans were two, which were distinguished as *Kumara-rea*, possessing a white skin and yellowish flesh, and *Kumara-tea*, which had a white skin and white flesh. Of late years many varieties have been introduced from Tahiti, Samoa, &c., and these appear to be preferred to the original stock.

Universally cultivated in warm regions; native country uncertain.

IPOMŒA sp.—Hills behind Maungaroa, not uncommon. Flowers in 5-10-flowered cymes, white, fugacious.

SOLANACEÆ.

*LYCOPERSICUM ESCULENTUM, Miller.—The Tomato is cultivated throughout the island, and is frequently seen in a semi-naturalized state.

Tropical America.

SOLANUM REPANDUM, Forst.—Native name *Rirei.* Open places in woods, but not very abundant. Formerly cultivated by the natives for the sake of the large edible berries.

Fiji Islands, Society Islands, Marquesas.

SOLANUM UPORO, Dun.—Native name *Poroiti.* Common all round the lower portion of the island. The bright red berries are eaten by the natives, and are also strung into necklaces. In former times the leaves were used to wrap up human flesh when being cooked for cannibal feasts.

New Caledonia and Fiji eastwards to the Society Islands and Marquesas.

SOLANUM OLERACEUM, Dun.—Native name *Poro.* Common in waste places, near cultivations, &c., and often planted about the dwellings of the natives, who use it as a potherb.

Widely spread in tropical climates.

*SOLANUM AURICULATUM, Ait.—Copiously naturalized in the valleys behind Avarua, and increasing fast.

Tropical America.

*PHYSALIS PERUVIANA, Linn.—The "Cape Gooseberry" is frequently seen in a naturalized state near the villages of the natives.

Originally from South America, but now cultivated or naturalized in all warm countries.

*PHYSALIS MINIMA, Linn.—A weed in waste places and cultivations, not common.

Tropics of the Old World.

*CAPSICUM FRUTESCENS, Linn.—Introduced by the first missionaries and traders, and now plentiful through the whole of the lower portion of the island, even far from cultivations.

Universally cultivated in the tropics; native country uncertain.

*CAPSICUM CERASIFORME, Miller.—Naturalized near Ngatangiia, but not common.

Tropical America.

*DATURA STRAMONIUM, Linn.—A weed in the cultivations of the natives at Arorangi and Ngatangiia, but by no means common.

Most tropical and temperate regions.

*NICOTIANA TABACUM, Linn.—The common tobacco is cultivated by the natives to a limited extent, and is often seen in a naturalized condition, especially in moist rich soils.

A native of America, but now cultivated in all countries.

SCROPHULARIACEÆ.

VANDELLIA CRUSTACEA, Benth.—Common on dry hills, usually at the base of larger plants.

Tropics of the Old World.

GESNERACEÆ.

CYRTANDRA RAROTONGENSIS, Cheesem., sp. nov. (Plate **35**.)—Frutex 6–12-pedalis; rami robusti, quadrangulares, juniores ferrugineo- vel fulvo-pubescentes. Folia magna, opposita, sæpe inæqualia, 5–12 poll. longa, 2–5 poll. lata, late et oblique oblonga vel elliptico-ovata, breviter acuminata, basi inæqualia, membranacea, irregulariter crenato-dentata, in utraque facie a pilis velutinis minutis inspersa, secus nervos dense fulvo-pubescentia; petiolus brevis, robustus, velutino-puberulus. Cymæ axillares, multifloræ; pedunculi 1½–2 poll. longi, dense ferrugineo-villosi; pedicelli circ. ⅓ poll. longi. Calyx ½ poll. longus, fere ad basin 3-fissus, deciduus, segmentis oblongo-lanceolatis, acuminatis. Corolla alba, glabra, quam calyx paullo longior, tubo ad basin ventricoso. Ovarium glabrum; stylus brevis, minute pilosus. Bacca ⅓ poll. longa, elliptico-oblonga, alba, succosa.

A fine handsome plant, only seen in two localities—on one of the northern spurs of Mount Maungaroa, and by the Avana stream at Ngatangiia. I cannot refer it to any of the species given by Mr. C. B. Clarke in his revision of the Cyrtandreæ in De Candolle's 'Monographiæ Phanerogamarum,' but it evidently falls into his section Polynesicæ, and is probably allied to *C. taitensis*, Rich.

MYOPORACEÆ.

MYOPORUM sp.—Native name *Ngaio*. A few trees only, planted in the gardens of the natives, and said by them to have been brought from the island of Mangaia, distant about 130 miles to the east of Rarotonga. It is very closely allied to the New Zealand *M. lætum*, if not identical with it.

VERBENACEÆ.

VITEX TRIFOLIA, Linn.—Native name *Rara*. Abundant in moist or swampy places near the sea.

Polynesia, from Fiji and Tonga to the Marquesas and Sandwich Islands; shores of tropical Asia and Africa.

LABIATÆ.

*OCIMUM BASILICUM, Linn.—Common in waste places, abandoned cultivations, &c., and often planted in the gardens of the natives.

Most warm countries.

*COLEUS BLUMEI, Benth.—Largely planted by the natives in their graveyards, and has established itself in many places. I was told that it was introduced by way of Samoa about fifteen years ago. The genus is a difficult one, and I am not sure that the species is rightly determined.

*SALVIA OCCIDENTALIS, Sw.—A most abundant and troublesome weed in the cultivations of the natives.

Tropical America.

*SALVIA COCCINEA, Juss.—Common by the sides of roads and near the villages of the natives; probably a garden escape.

Native of tropical America, now established in many warm countries.

*LEONURUS SIBIRICUS, Linn.—Roadsides, waste places, &c.; not common.

Either native or naturalized in most tropical countries.

PLANTAGINACEÆ.

*PLANTAGO MAJOR, Linn.—Roadsides and waste places at Avarua, not seen elsewhere. Doubtless a recent introduction.

All warm and temperate countries.

NYCTAGINACEÆ.

*MIRABILIS JALAPA, Linn.—Now widely distributed throughout the island, and presenting all the appearance of a true native. The Rarotongans, however, recognize that it is an intruder from abroad, originating from the gardens of the first missionaries.

Originally from Mexico, now widely spread in tropical countries.

PISONIA INERMIS, Forst.—Dark woods, not common. Slopes of Mount Mangatea; summit of Tekou, at 1800 ft.

Pacific Islands from Fiji to the Paumotu Group and the Sandwich Islands, North Australia.

BOERHAAVIA REPENS, Linn., var. DIFFUSA, Hook. f.—A common weed by roadsides, waste places, &c.

Most warm countries.

AMARANTACEÆ.

*AMARANTUS PANICULATUS, Linn.—Not uncommon in waste places, abandoned gardens, &c.

Most warm climates.

*AMARANTUS VIRIDIS, Linn.—Plentiful in cultivated ground, waste places, &c. A very troublesome weed.

Native country uncertain, now found in all warm climates.

ACHYRANTHES ASPERA, Linn.—Lower portions of the island, not uncommon.

Throughout Polynesia and in most warm countries.

CYATHULA PROSTRATA, Blume.—Shaded places in the lower part of the island, not very common.

Polynesia, and in tropical Asia, Africa, and America.

PHYTOLACCACEÆ.

*PHYTOLACCA OCTANDRA, Linn.—Tukavaine Valley and slopes of Mangatea, scarce at present, and probably a recent introduction from New Zealand, in the northern part of which it is plentifully naturalized.

Tropical America, now widely spread in warm countries.

PIPERACEÆ.

PIPER METHYSTICUM, Forst.—Native name *Kava*. Only known in Rarotonga as a cultivated plant, and now far from common, the use of it being discountenanced by the missionaries. The natives say they brought it with them when the island was first colonized, a statement most probably correct.

Throughout Polynesia.

Piper latifolium, Forst.—Native name *Kakara-atua*. Very abundant in the wooded portions of the island, at low elevations, in many places forming the chief undergrowth.

Throughout the Pacific Islands.

Peperomia leptostachya, Hook. & Arn.—Common on rocks, trunks of trees, &c.

Tonga to the Marquesas and Sandwich Islands, North Australia.

Peperomia rhomboidea, Hook. & Arn.—Common in hilly forests, forming clumps at the roots of trees, &c.

Society Islands.

CHLORANTHACEÆ.

Ascarina lanceolata, Hook. f.—Plentiful on the summit of all the mountains, at 1000-2200 ft. I refer this to *A. lanceolata* on account of its narrow leaves, but I must admit that I am not satisfied of its distinctness from *A. polystachya*, Forst.

Fiji, Samoa, Kermadec Islands, New Zealand.

LAURACEÆ.

*Persea gratissima, Gærtn.—Introduced from Tahiti about twenty-five years ago, and has reproduced itself abundantly in several localities.

Tropical America.

Cassytha filiformis, Linn.—Common near the sea-beach, usually parasitic on *Scævola Kœnigii*.

Pacific Islands, and shores of most tropical countries.

Hernandia peltata, Meisn.—Native name *Puka*. Plentiful all through the lower portion of the island, but not extending far inland. It attains a considerable height, but old specimens are often hollow. It is the timber generally employed for making canoes.

Throughout Polynesia, also in North Australia, Tropical Asia, and Africa.

Hernandia Mœrenhoutiana, Guill.—Native name *Turina*. Not uncommon in wooded valleys and ravines, extending further into the interior of the island than the preceding species.

Tonga, Society Islands.

LORANTHACEÆ.

Loranthus insularum, A. Gray.—Native name *Pauma*. Woods of the interior, usually parasitic on *Fitchia* or *Inocarpus*, not very common. A very handsome plant when in flower, from the abundant orange-red flowers.

Fiji to Tahiti.

Viscum articulatum, Burm. f.—Parasitic on *Plectronia* at Papua, on the south side of the island. Not seen elsewhere, but it is easily overlooked.

Pacific Islands, Australia, Tropical Asia.

THYMELÆACEÆ.

Wikstrœmia viridiflora, Meissn. (*W. indica*, C. A. Mey.)—Hills of the interior, not common. Slopes of Maungaroa, 800–1200 ft.; Tekou, 800–1800 ft.; Papua, 800–1200 ft. I am not at all sure that the identification is correct; the branches seem to be too silky and the leaves too large.

Pacific Islands and Australia, northwards to Malaya, India, and China.

EUPHORBIACEÆ.

Euphorbia Chamissonis, Boiss.—Not uncommon in open places near the sea, also noticed on several of the rocky peaks in the interior.

Fiji Islands.

*Euphorbia pilulifera, Linn.—A common weed by roadsides, in waste places, and abandoned cultivations.

Most warm countries.

*Euphorbia humifusa, Willd.—A weed in native cultivations at Arorangi, doubtless a recent introduction.

Now common in most warm countries.

*Euphorbia pulcherrima, Willd.—Commonly planted in the gardens of the natives, often rendering them a blaze of colour.

Originally from Mexico and Central America, but now planted and naturalized in many warm countries.

*Euphorbia heterophylla, Willd.—Plentifully naturalized in waste places at Avarua, but its origin can easily be traced to a garden in the vicinity.

Tropical America.

*Phyllanthus Niruri, Linn.—Waste places and roadsides, very plentiful all round the island.

All tropical countries except Australia.

Phyllanthus simplex, Retz.—Dry hills in the interior, not uncommon.

Pacific Islands and Australia, and northwards to the Malay Archipelago, India, and China.

Bischofia javanica, Blume.—Native name *Koka.* A tree plentiful in the lower parts of the island.

New Caledonia to Tahiti, and northwards to Malaya and India.

Aleurites moluccana, Willd.—Native name *Tuitui.* Abundant throughout the island from sea-level to over 1000 ft., in the hilly districts often forming a large proportion of the forest. The natives still string the oily seeds and use them as candles, as in so many other parts of Polynesia.

Throughout the Pacific Islands from the Sandwich Islands on the north to the Kermadec Islands on the south; also in Australia, Malaya, and India.

Codiæum variegatum, Blume.—Commonly cultivated by the natives for ornament, but I doubt its being truly indigenous, although it may have been introduced before the arrival of Europeans.

Western Pacific, and northwards to the Malay Archipelago.

*Manihot utilissima, Pohl.—Introduced by the first missionaries, and now extensively cultivated, also established in many places as a naturalized plant.

Tropical America.

Acalypha tricolor, Seem.—Largely planted by the natives on account of its brilliant foliage, and probably introduced by them in very early times.

Fiji, Samoa.

Acalypha, sp. nov.—Shaded woods near Arorangi, not common. I had referred this with doubt to *A. insulana*, Muell. Arg., but the Kew authorities report it as undescribed.

Macaranga Harveyana, Muell. Arg.—Native name *Enua.* Common in forests, ascending the hills to 1000 ft. alt. Often planted for shade near the native villages.

Pacific Islands from Fiji to Tahiti.

*Ricinus communis, Linn.—Cultivations and waste places, plentifully naturalized.

Originally from Africa, now spread through the world in warm countries.

Homalanthus pedicellatus, Benth.—Rare. Summit of Mount Taitukura, 1800–2000 ft.; Mount Tekou, 1500–1800 ft.

Pacific Islands, from New Caledonia eastwards to Tahiti.

URTICACEÆ.

Broussonetia papyrifera, Vent.—Native name *Aute.* When the island was first discovered this was largely cultivated and used for the manufacture of cloth, as elsewhere in Polynesia. It is now almost extinct, and apparently restricted to a single locality on the eastern side of the island.

Through the Pacific Islands, Malaya, China.

Ficus prolixa, Forst.—Native name *Aoa*. The Banyan of the European settlers. Not common, but scattered irregularly over the whole of the lower parts of the island. In former times often planted for boundary-marks. A coarse kind of cloth was occasionally beaten out of the bark of the straighter branches.

New Caledonia eastwards to Tahiti and the Marquesas.

Ficus tinctoria, Forst.—Native name *Mati*. Woods on the lower part of the island, not common.

Fiji eastwards to Tahiti.

Artocarpus incisa, Linn.—Native name *Kuru*. Lower portions of the island, plentiful, but usually a little distance from the sea. According to the chief Tarare, the Bread-fruit was introduced by the natives from Tahiti, many generations before the arrival of Europeans. It still forms a large proportion of their food. Many varieties exist, the best being (1) *Kuru-atu*, (2) *Tatara*, (3) *Patea*, (4) *Kuru-maori*. In olden times the fruit was cooked by wrapping it in green leaves and then placing it on hot embers; but it is often now baked in European fashion. It was sometimes eaten raw, but was then allowed to become fully ripe or almost rotten. Great quantities were preserved by burying the perfectly ripe fruit (which has the consistency of paste) in pits in the ground, the sides of which were lined with banana-leaves, and the top covered with the same leaves well pressed down by a thick layer of earth or stones. If care was taken to renew the leaves periodically this paste—or "Mai," as it was called—would keep for more than a year, and was considered a great delicacy. It is now seldom made, and I had some difficulty in obtaining a small quantity. It has a most objectionable smell, looks somewhat like soft cheese, and has a sharp and acid taste.

Pacific Islands.

Fleurya interrupta, Gaud.—Shady places in the valleys, and a weed in the cultivations of the natives.

Pacific Islands and Australia, and northwards to Malaya, India, and China. Also in East Africa.

Pellionia elatostemoides, Gaud.—Common at the roots of trees in hilly forests.

Fiji Islands, Marquesas, New Guinea, Moluccas.

Cypholophus macrocephalus, Wedd.—Hills of the interior, not common. Maungaroa; slopes leading to Ikurangi; hills behind Ngatangiia. Seems to have much larger leaves than the typical form.

Pacific Islands and northwards to Sumatra.

Pipturus velutinus, Wedd.—Native name *Orongo*. Common all round the island at low elevations.

Throughout the Pacific Islands.

LEUCOSYKE CORYMBULOSA, Wedd.—Native name *Rauriki*. Plentiful on rocky slopes, the steep sides of ravines, &c., all through the island.

Fiji Islands.

CASUARINACEÆ.

CASUARINA EQUISETIFOLIA, Forst.—Native name *Toa*, "Iron-wood" of the European settlers. Common along the shores, in many places forming a belt just above high-water mark. Also capping some of the dry hills in the interior. Wood used for clubs or spears. for the posts of houses, and for any purpose for which extreme hardness and durability are required.

Tropical shores of the Old World.

ORCHIDEÆ.

MICROSTYLIS PLANTAGINEA, Steud. ?—Common in shaded places in the interior of the island. Flowers not seen, and identification consequently doubtful.

Pacific Islands, Malaya.

OBERONIA GLANDULOSA, Lindl.—Branches and trunks of trees, often seen in the interior of the island.

Fiji, Samoa, Tahiti.

LIPARIS CLYPEOLUM, Lindl.—Shaded and mossy places near the summits of the hills, 1000–2000 ft. alt. My specimens differ from Lindley's description in the more numerous flowers and the cuspidate labellum, but Mr. R. A. Rolfe, of the Kew Herbarium, places them under *L. Clypeolum*.

Tahiti.

BULBOPHYLLUM sp. ?—Branches and trunks of trees. common in the interior of the island. Rhizome wide-creeping, furnished with numerous large pseudo-bulbs, each bearing at the apex a single oblong fleshy and coriaceous leaf, 3–4 in. long. Flowers not seen.

PHAIUS GRANDIFOLIUS, Lour.—Native name *Nutupa*. Common in damp shaded places on the mountains and along most of the ravines. A very beautiful plant, with broad plaited leaves 3–5 ft. long, and stout scapes almost as tall, bearing 12–18 large flowers 2¼ in. long. The lateral petals and sepals are cream-coloured on the outside, on the inside a rich brownish purple shading into violet; the lip is pale yellow streaked with purple or violet.

Pacific Islands, Australia, Malaya, China.

TÆNIOPHYLLUM ASPERULUM, Reichb. f.—Hills of the interior, plentiful on the trunks and branches of trees. I am indebted to Mr. R. A. Rolfe for this determination.

Society Islands.

HABENARIA AMPLIFOLIA, Cheesem., sp. nov.—Caulis 1–3-pedalis, teres, validus, ¾–1 poll. crassus, infra medium vaginatus, superne foliosus. Folia 5–10, congesta, patentia, rosulata, oblongo-lanceolata vel lineari-lanceolata, acuminata, tenuiter membranacea, læte virentia, nitida, venis conspicuis. Pedunculus 6–12 poll. longus, fere ad inflorescentiam vaginatus, superne racemosus. Racemus 4–9 poll. longus, laxus, multiflorus. Flores mediocres, virides, pedicellati, bracteis ovarium subæquantibus. Sepala ⅓–½ poll. longa, subæqualia, oblonga vel oblongo-ovata, acuminata. Petala fere ad basin bipartita, lobo antico multo breviore. Labellum 3-partitum, lobis lateralibus linearibus brevioribus, lobo medio lineari-lanceolato longiore. Calcar gracile, fere pedicello æquilongum. Columna brevis, crassa, processibus stigmaticis oblongo-clavatis.

Plentiful in deep shaded ravines all through the island. Mr. Rolfe informs me that its nearest ally is *H. superflua*, Reichb. f., from the Fiji Islands; and I suppose it is also related to the Indian *H. macrostachya*, Lindl.

—— ?—Habit much like that of an *Earina*. Stems numerous, 1½–2 ft. long, bearing numerous distichous alternate lanceolate leaves 2–3 in. long. Flowers and fruit not seen. Apparently common in woods.

—— ?—Small. Leaves tufted, 3–5, rarely more, linear-oblong, 1–2 in. long. Spikes 2 or 3 at the base of the leaves. Flowers not seen. Capsule ½ in. long, sessile. Hills near Maungaroa, on the branches of trees, rare.

SCITAMINEÆ.

*HEDYCHIUM sp.—Naturalized about the houses of the natives. Good flowering specimens not seen.

CURCUMA LONGA, Linn.—Plentiful in the lower portions of the island and in many of the ravines. Root used by the natives for making curries and for dyeing.
Indigenous or cultivated throughout the tropics.

*ALPINIA NUTANS, Rosc.—Naturalized about the villages of the natives, and often planted by the European settlers.
India and Malaya.

SCITAMINEA ?—Native name *Kopi*. Commom all through the island, ascending the hills to a considerable height. Flowers and fruit not seen. Plant about the size of *Curcuma longa*, with much of its aspect.

*CANNA INDICA, Linn.—Native name *Nuaenga*. Extremely plentiful all through the lower portions of the island, and presenting all the appearance of a true native. It was probably introduced by the first missionaries.

Musa paradisiaca, Linn.—Abundant in suitable localities throughout the island. The Banana always has been and still is the staple article of food among the Rarotongans, and has been cultivated by them from time immemorial. The following list of 15 different varieties known before the arrival of Europeans was supplied to me by the chief Tarare, and he admitted that other kinds were grown, the names of which he had forgotten :—(1) *Turita*, the best variety, the fruit of which was reserved for the use of the chiefs; (2) *Koputea*; (3) *Rari*; (4) *Toanga*; (5) *Aumari*; (6) *Ai*; (7) *Raumaru*; (8) *Unauna*; (9) *Piraikura*; (10) *Mava*; (11) *Kaivao*; (12) *Torota*: (13) *Kirimangio*; (14) *Tapua*; (15) *Rokivi*.

Universally cultivated in warm climates.

Musa Fehi, Bertero.—Native name *Uatu*, meaning the "fruit which stands up," in allusion to the erect bunches of fruit, the bunches being pendulous in all the varieties of *M. paradisiaca*. It is also often called by its Tahitian name of *Fehi*, or rather *Fei*. It is most abundant in the central portions of the island, particularly at the sources of the mountain-streams, where it often forms groves of several acres in extent. It is rarely cultivated, the natives preferring to make regular expeditions to the heads of the valleys for the fruit. This is usually baked, seldom eaten raw.

Pacific Islands.

BROMELIACEÆ.

*Ananas sativa, Linn.—The Pine-apple is largely cultivated, the fruit being regularly exported to Auckland. It has gone wild in several localities, and I noticed plants growing in the forest on the summit of Tekou, at an elevation of 1800 ft., far away from all plantations.

Tropical America.

AMARYLLIDACEÆ.

Crinum pedunculatum, R. Br.—Very plentiful near the villages of the natives, and often planted in their gardens. Doubtless an introduced plant.

Pacific Islands, Australia, Malaya.

DIOSCOREACEÆ.

Dioscorea alata, Linn.—Native name *Ui-parai*. Abundant throughout the lower portions of the island, but not so frequently cultivated as the following species.

Pacific Islands, India, Malaya.

Dioscorea sativa, Linn.—Native name *Oi*. This is the Yam which is most frequently cultivated in Rarotonga. The natives distinguish eight or ten varieties.

Cultivated in most warm climates.

Dioscorea pentaphylla, Linn.—Native name *Pirita*. Common on the lower parts of the island, festooning trees. It is much prized by the natives for food, but I did not see it in cultivation, like the two preceding species.

Pacific Islands, India, Malaya, tropical Africa.

LILIACEÆ.

Cordyline terminalis, Kunth.—Native name *Ti.* Common in the interior, ascending to the tops of the highest peaks, 1800–2200 ft. alt. In olden times several varieties were cultivated for the sake of the large tuberous root, and it is still occasionally planted. The root was bruised, mixed with the "Kape" (*Alocasia*), and then baked for a whole day.

Throughout the Pacific Islands, either wild or cultivated, and extending northwards to India and Burma.

Dianella intermedia, Endl.—Native name *Pui.* Abundant on dry hills, ascending to 2000 ft. Attains a much larger size than in New Zealand.

From Fiji to Tahiti, and southwards to Norfolk Island and New Zealand.

COMMELINACEÆ.

*Commelina nudiflora, Linn.—Common all round the island in damp places. The natives cut it for forage for their horses.

Most warm countries.

PALMÆ.

Cocos nucifera, Linn.—Native name *Nu.* The Cocoa-nut is abundant in the lower portions of the island, from high-water mark to perhaps 300 ft. alt. The natives state that there are five varieties, which they distinguish mainly by the size and colour of the fruit. Their names are *Nu-kura*, *Nu-uri*, *Nu-tea*, *Nu-mangaro*, and *Nu-mura.*

Most tropical shores.

PANDANACEÆ.

Pandanus odoratissimus, Linn.—Native name *Ara.* Common along the coast, often forming the chief vegetation just above high-water mark. It also ascends the hills to at least 800 ft.

Polynesian Islands and northwards to tropical Asia.

Pandanus sp.—Native name *Rauara.* A small species, hardly more than 6 or 8 ft. in height, with soft flexible leaves, which are not nearly so spinose on the margins and midrib as in the preceding. I did not see either flowers or fruit. It prefers moist places, and is often cultivated by the natives, who use the leaves for making sleeping-mats, baskets, &c. They all agree in stating that it is a distinct plant from the foregoing, never attaining a large size. It is probably the same as the plant referred by Seemann to *P. caricosus*, Rumph., in the 'Flora Vitiensis' (p. 281).

Freycinetia, sp. nov.—Native name *Kie-kie.* Very abundant on the mountains, scrambling up the trunks of trees or over rocks, often rendering the forest almost impenetrable. Unfortunately I failed to find either flowers or fruit.

AROIDEÆ.

Amorphophallus campanulatus, Blume.—Native name *Pia*. A very abundant plant in the lower portions of the island.

Many warm climates.

Colocasia antiquorum, Schott, var. esculenta, Engl.—Native name *Taro*. Extensively cultivated by the natives, sometimes in dry ground, but more generally in artificial ponds or rather swamps, often of large size.

Cultivated in most warm climates.

Alocasia macrorhiza, Schott.—Native name *Kape*. Almost as commonly cultivated as the foregoing, and often planted on the embankments of the Taro-ponds. The leaves sometimes attain an enormous size, one specimen that I measured exceeding 13 feet, including the petiole.

Cultivated in most tropical countries.

Epipremnum mirabile, Schott.—Native name *Pikimato*. Low-lying places and ravines a little distance from the sea, scrambling up the trunks of trees to a considerable height. I did not see flowers or fruit, and am indebted to Mr. N. E. Brown for the determination.

Pacific Islands and northwards to Java.

CYPERACEÆ.

(I am indebted to Mr. C. B. Clarke, F.R.S., for the determination of the species.)

Cyperus rotundus, Linn.—Waste places near Avarua, not seen elsewhere. Perhaps introduced only.

A weed in all warm countries.

Kyllinga monocephala, Rottb.—Common by the sides of roads, &c., and in the cultivations of the natives.

Pacific Islands, tropical Asia, and Africa.

Mariscus albescens, Gaud.—Common in moist places, by water-holes, &c.

Pacific Islands and tropics of the Old World.

Mariscus albescens, Gaud., var. β. ventricosa, C. B. Clarke.—In similar situations to the preceding.

Sandwich Islands, Tonga, Australia.

Mariscus cyperinus, Vahl.—Very plentiful in open or shaded, damp or dry places, and apparently exceedingly variable.

Pacific Islands, plentiful.

MARISCUS SIEBERIANUS, Nees, var. SUBCOMPOSITA, C. B. Clarke.—Ravines towards the centre of the island, not common.

Tropics of the Old World.

MARISCUS MACROPHYLLUS, Brongn.—Taro-swamps in the upper part of the Tukavaine valley, not common.

Society Islands.

TORULINIUM CONFERTUM, Ham. (*Mariscus ferax*, C. B. Clarke).—In Taro-swamps and in moist places by the sides of streams, at Matavera, Ngatangiia, &c.

All warm countries.

FIMBRISTYLIS DIPHYLLA, Vahl.—Plentiful on open dry hills, and in sandy places near the seas.

Most warm countries.

FIMBRISTYLIS CYMOSA, R. Br., var. SUBCAPITATA, C. B. Clarke.—Moist or sandy places near the sea, apparently not common.

New Caledonia to the Sandwich Islands.

GRAMINEÆ.

(I am much indebted to Prof. E. Hackel for examining and determining a set of my Rarotongan grasses, and for contributing the descriptions of the two new species. I have also to express my thanks to Dr. Otto Stapf for critical remarks on several of the species.)

PASPALUM SCROBICULATUM, Linn.—Native name *Mata*. Dry hills, plentiful, often growing intermixed with *Gleichenia dichotoma*.

Almost all warm countries.

PASPALUM DISTICHUM, Linn.—Muddy places on the shore of Ngatangiia Harbour, not seen elsewhere. Identified from habit and foliage alone, the plant not being in flower at the time of my visit.

All warm countries.

*PASPALUM CONJUGATUM, Berg.—Fields and waste places at Avarua, not seen elsewhere; most likely a recent introduction.

Most warm climates.

*PANICUM MAXIMUM, Jacq.—Largely cultivated by the natives as forage for their horses, and often holds its own in abandoned cultivations.

Tropical Africa.

PANICUM AMBIGUUM, Trin.—Open places throughout the island, plentiful.

Pacific Islands, northwards to Malaya and India.

PANICUM PILIPES, Nees et Arn.—Fringing the sides of water-courses at the foot of the hills, not common.

Pacific Islands and Australia, northwards to Malaya and Ceylon, Mauritius and Madagascar.

PANICUM (§ DIGITARIA) SANGUINALE, Linn.—Everywhere in the cultivated parts of the island. Two varieties are common, which Prof. Hackel identifies as var. *vulgare*, Doell, and var. *timorense*, Hackel.

Cosmopolitan in warm climates.

ISACHNE DISTICHOPHYLLA, Munro, in Hillebrand, Flora of the Hawaiian Islands, p. 504 ?—Summit of Mount Tekou, at 1800 ft.; Mount Taitukura, at 1500–2000 ft. A remarkable species, with hard, woody, bamboo-like stems 3–6 ft. high. Prof. Hackel remarks that "the description coincides well, but in your specimens the spikelets are not always quite glabrous as in the Hawaiian plant, but this is a character somewhat variable in many species of *Isachne*." Dr. Stapf states that it was also collected in Rarotonga by Mr. T. B. Cartwright in 1889.

OPLISMENUS COMPOSITUS, Beauv.—Shaded places at low elevations throughout the island, very plentiful. A very variable plant. One form approaches *O. undulatifolius*, Beauv., another is identified by Dr. Stapf with a plant named *O. æmulans*, R. Br., by the late General Munro.

All warm countries.

CENCHRUS ECHINATUS, Linn.—Roadsides, waste places, &c.: a most troublesome weed.

A common tropical weed.

*STENOTAPHRUM AMERICANUM, Linn.—Has been introduced by the European settlers, and is fairly well established in several places.

Tropical regions generally.

STENOTAPHRUM SUBULATUM, Trin.—Common in shaded and sandy places near the sea.

Pacific Islands, Malay Archipelago, Mauritius.

THUAREA SARMENTOSA, Pers.—Sandy shores, common just above high-water mark.

Throughout the Pacific Islands, also in the Malay Archipelago and Mauritius.

GARNOTIA CHEESEMANI, Hackel, sp. nov.—"Perennis. Culmus adscendens, circ. 30 cm. altus, valde ramosus, gracilis, teres, glaberrimus, dense foliatus, apice breviter nudus. Folia glabra; vaginæ subcompressæ, internodia plerumque superantes, ore nudæ; ligula membranacea, brevissima, truncata, denticulata; laminæ anguste lineares, planæ vel siccitate subconvolutæ, 12–16 cm. longæ, 2·5 mm. latæ, sensim tenuissime acuminatæ, erecto-patulæ, præter marginem scabrum læves, tenuinerves. Panicula lineari-oblonga circ. 9 cm. longa, stricta, haud vel vix basi interrupta, rhachi lævi, ramis binis vel ternis 1·5–2·5 cm. longis suberectis simplicibus a basi spiculis densiuscule obsitis. Spiculæ secus paniculæ ramos geminæ, altera pedicello brevissimo, altera eam subæquante crassiusculo subclavato fulta, lineari-lanceolatæ, 3·5 mm. long., virides. Glumæ steriles subæquales, lineari-lanceolatæ, acutæ, ex apice obsolete bidentulo mucronem 0·5–1 mm. longum, scabrum, exserentes, 3-nerves, nervis valde prominentibus superne aculeolato-scabris, inferior basi (in callo) minute barbulata. Gluma florifera sterilibus subbrevior, lanceolata, tenuissime 3-nervis, glaberrima, inter apices dentium brevissimorum aristam emittens tenuem haud geniculatam neque tortam sed leviter flexuosam 5 mm. longam (gluma ipsa fere duplo longiorem) scabram. Palea gluma paullo brevior, lanceolata, acuta, binervis. Caryopsis lanceolato-fusiformis, 1·5 mm. longis, embryone dimidiam caryopsin æquante, macula hilari punctiformis.

"Rarotonga in saxosis montium rara. Legit T. F. Cheeseman, Jul. 1899.

"Affinis *G. strictæ*, Brongn., quæ vero abunde differt foliis late linearibus ore pilosis, paniculæ interruptæ ramis verticillatis fastigiatis, spiculæ gluma inferior basi distincte barbata (barba circ. $\frac{1}{5}$ glumæ æquante) gluma florifera (saltem in planta typica) mutica. *G. Fergusonii*, Trim., habitu nostræ similis, differt foliis pilosis, spiculis majoribus (5 mm. longis), gluma inferiore mutica."

I had referred this to *G. stricta*, but Prof. Hackel states that it is clearly distinct, and has supplied me with the above diagnosis and notes.

MISCANTHUS JAPONICUS, Anderss.?—Native name *Kakao*. Very plentiful on open hill-sides throughout the island, and much used for lining the native houses, &c. My specimens are long past flower, and only show old panicles from which the spikelets have fallen, so that some little doubt attaches to the determination.

Pacific Islands northwards to Malaya, the Philippines, China, and India.

ERIANTHUS MAXIMUS, Brongn.?—Hill-sides above Arorangi, rare. I am indebted to Dr. Stapf for suggesting that this may be Brongniart's *E. maximus*, a species of which there is no authentic example at Kew.

Tahiti.

ANDROPOGON ACICULATUS, Retz.—Common in open places throughout the island, both near the sea and on the mountains.

Pacific Islands, Australia, and northwards to India and China.

ANDROPOGON REFRACTUS, R. Br.—Open rocky places on the hills, not uncommon.
New Hebrides, Fiji, Tahiti, Australia.

*ANDROPOGON HALEPENSIS, Brot., var. EFFUSUS, Hackel.—Introduced by the European settlers, and often cultivated for fodder. Has become wild in several localities.

Cultivated in all warm localities.

CYNODON DACTYLON, Pers.—Native name *Mati*. Roadsides and waste places in the lower part of the island, abundant.

All warm countries.

CHLORIS CHEESEMANI, Hackel, sp. nov.—"Perennis, cæspitosa. Culmi suberecti, graciles, circ. 40 cm. alti, teretes, multinodes, e nodis inferioribus ramosi, glaberrimi. Vaginæ arctæ, internodia æquantes vel superantes, subcompressæ, glaberrimæ nisi faucibus longi molliterque fimbriatæ. Ligula obsoleta. Laminæ anguste lineares, setaceo-acuminatæ, planæ vel subcomplicatæ, ad 12 cm. long., 1·5–3 mm. lat., glabræ, margine scabræ, virides. Spicæ 3–4, digitatæ, erectæ (etiam fructiferæ), graciles, circ. 8 cm. long., rhachi glabra, scabra; spiculæ subimbricatæ, appressæ, 4–5 mm. longæ, sordide violascentes vel nigrescentes; glumæ steriles inæquales (inferior $\frac{1}{3}$ brevior), lineari-lanceolatæ, subulato-mucronatæ, integræ, inf. 1-nervis, sup. 3-nervis, nervis aculeolato-scabris. Gluma floris ☿ lineari-lanceolata, 4 mm. longa, callo breviter barbata, apice inter dentes 2 subuliformes breves aristam rectam circ. 5 mm. longam exserens, 3-nervis, carinata, superne scabra; ejus palea quam gluma paullo brevior, bicarinata, carinis superne scabris. Antheræ 1 mm. longæ. Flos sterilis unicus, pedicello glabro quam gluma florens 3–4-plo breviore fultus, circ. 2 mm. longus, uniglumis; gluma lineari-oblonga, superne aculeolato-scabra, apice integro in aristam circ. 4 mm. longam abiens, sine palea et sine rhachillæ continuatione.

"Rarotonga, in locis saxosis montium rara. Julii, 1899, leg. T. F. Cheeseman.

"Affinis *C. divaricatæ*, R. Br., quæ vero differt spicis 6–12 demum divaricatis, floris sterilis gluma apice biloba, inter lobos aristata. Eadem nota (floris sterilis) differt *C. cynodontoides*, Bal., quæ ceterum rhizomate repente, foliisque obtusis distinguitur."

ELEUSINE INDICA, Gærtn.—Common, especially in waste places near dwellings, &c.

All warm countries.

CENTOTHECA LAPPACEA, Desv.—Native name *Mauku-tonga*. Ravines and in rich alluvial soils, plentiful.

Pacific Islands, Australia, tropical Asia, and Africa.

ERAGROSTIS PLUMOSA, Link.—Native name *Mauku*. Common everywhere in fields and waste places in the lower part of the island.

Polynesia and northwards to India and Ceylon.

Lepturus repens, R. Br.—Limestone rocks at the entrance to Ngatangiia Harbour; not seen elsewhere.

Pacific Islands, Australia, Malaya, Ceylon.

FILICES.

(Mr. C. H. Wright verified most of my determinations of the Ferns.)

Gleichenia dichotoma, Sw.—Native name *Tuanui*. Abundant on dry open hills, in very barren places sometimes forming the chief vegetation.

Throughout the Pacific Islands and in most warm countries.

Cyathea Milnei, Hook.—Native name *Eki*. Not common. Slopes of Maungaroa and gullies at its foot; head of Tukavaine Creek; near Papua. Caudex 6–15 ft., stout. Fronds 6–10 ft.; main rhachis muricate. Involucres very fragile.

Pacific Islands as far south as the Kermadec Islands.

Cyathea sp.—Not seen except on spurs near the summit of Mount Taitukura, alt. 1800–2000 ft. Caudex 4–8 ft., rather stout. Fronds 4–6 ft. Fructification not seen.

Alsophila decurrens, Hook.—Native name *Eki*. Sparingly found on all the mountains, but far from common. Caudex 4–15 ft., often not much thicker than a man's arm. Fronds 5–8 ft.

Pacific Islands, from the New Hebrides to Tahiti.

Trichomanes apiifolium, Presl.—Near the source of the Avana stream at Ngatangiia, abundant, but not seen elsewhere. Fronds (with the stipes) often over 2 ft. high.

Pacific Islands, Malay Archipelago, Philippines.

Trichomanes rigidum, Sw.—Common in damp shaded places on the mountains.

Most warm countries.

Trichomanes humile, Sw.—Faces of rocks in shaded ravines, not uncommon.

Java, Pacific Islands, New Zealand.

Trichomanes digitatum, Sw.—Summit of Mount Tekou, on trunks of trees; not seen elsewhere.

Tropics of the Old World.

Trichomanes filicaule, Bory.—Common in shaded ravines, among moss, &c.

Tropics of the Old World.

Hymenophyllum polyanthos, Sw.—Mossy places on the mountains, often forming large patches.

All tropical countries and some temperate ones.

DAVALLIA (§ HUMATA) PECTINATA, Smith.—Common on trunks of trees throughout the island, from sea-level to the tops of the hills.

Pacific Islands.

DAVALLIA (§ ODONTOLOMA) REPENS, Desv.—Summits of the higher mountains, 1200–2200 ft., not common.

Pacific Islands, Malay Archipelago, Mauritius.

DAVALLIA (§ EUDAVALLIA) SOLIDA, Sw.—Most abundant throughout the whole of the island, from sea-level to the tops of the mountains.

Pacific Islands, Malay Archipelago.

DAVALLIA (§ EUDAVALLIA) ELEGANS, Sw.—With the preceding, but not so plentiful.

Pacific Islands and tropics of the Old World.

DAVALLIA (§ MICROLEPIA) SPELUNCÆ, Baker.—Common in woods in the lower part of the island.

Tropics of the Old World.

DAVALLIA (§ STENOLOMA) TENUIFOLIA, Sw.—Dry hills, plentiful, both in open places and in light forest.

Pacific Islands, tropical Asia, Mauritius, and Madagascar.

DAVALLIA (§ LOXOSCAPHE) GIBBEROSA, Sw.—Abundant in woods in the central part of the island, ascending to the tops of the highest peaks, alt. 2200 ft.

Pacific Islands.

LINDSAYA LOBATA, Poir.—Not uncommon in the central and hilly parts of the island.

Fiji to Tahiti, Australia, Malaya, India.

ADIANTUM HISPIDULUM, Sw.—Rocky places and the sides of dry gullies, frequent.

Pacific Islands, New Zealand, Australia, and northwards to India, South Africa.

HYPOLEPIS TENUIFOLIA, Bernh.—Apparently not common, Avatiu stream; near Ngatangiia.

Pacific Islands, New Zealand, Australia, Malaya.

PTERIS INCISA, Thunb.—Native name *Arerupe.* Open places on the hills of the interior, not uncommon.

Most warm climates.

PTERIS MARGINATA, Bory.—Not common. Black Rock; Tukavaine Valley; near Titikaveka.

Tropics of the Old World.

Pteris comans, Forst.—Rich alluvial soils by the side of the larger streams, common and attaining a great size.

Pacific Islands, Australia, New Zealand.

Lomaria vulcanica, Blume.—Summits of most of the hills, not uncommon. This is much larger than the New Zealand form, but has the adnate upper pinnæ and deflexed lower ones that mark the species.

Pacific Islands, New Zealand, Australia, Malaya.

Lomaria procera, Spreng.—Summits of Mounts Tekou and Taitukura, alt. 1800–2200 ft.

Most southern tropical and extratropical regions.

Asplenium Nidus, Linn.—Native name *Kotaa*. Extremely plentiful all through the island, from sea-level to the tops of the mountains.

Tropics of the Old World.

Asplenium tenerum, Forst.—Deep ravines at the sources of streams on the eastern side of the island, not common.

Pacific Islands, Malay Archipelago, India.

Asplenium falcatum, Lam.—Not uncommon on the higher mountains. Differs from the typical state in the pinnæ being hardly lobed and broader.

Warm regions of the Old World.

Asplenium resectum, Smith.—Ascent of Mount Taitukura, alt. 1800 ft.; not seen elsewhere.

Pacific Islands and Malay Archipelago northwards to India and Japan, tropical South Africa.

Asplenium lunulatum, Sw.—Deep shady places on the ascent of Mount Taitukura, alt. 1500–1800 ft.; not seen elsewhere. A very peculiar proliferous variety, which, I am informed by Mr. C. H. Wright, of the Kew Herbarium, is also found in Hawaii.

The typical state of the species universal in the tropics.

Asplenium horridum, Kaulf.—Not uncommon on the mountains, above 800 ft. elevation.

Polynesian Islands, Malay Archipelago.

Asplenium cuneatum, Lam.—Abundant all through the island, in gullies, by water-courses, &c.

Most warm countries.

Asplenium (§ Diplazium) japonicum, Thunb.—Moist places near the source of the Tukavaine Creek; not seen elsewhere.

Fiji to Tahiti, New Zealand, India, China, Japan.

Asplenium (§ Diplazium) arborescens, Mett.—Common by the sides of the larger streams, especially in rich alluvial soils.

Pacific Islands, Mauritius, and Madagascar.

Blechnum orientale, Linn.—Native name *Moumea*. Plentiful on dry hills all over the island.

Pacific Islands, Australia, East Tropical Asia.

Doodia media, R. Br., var. connexa, Baker.—Near the summits of most of the mountains, not uncommon.

Pacific Islands, New Zealand, Australia.

Aspidium aristatum, Sw.—Abundant in woods all through the island.

Pacific Islands, and most warm regions of the Old World.

Nephrodium leucorhachis, Cheesem., sp. nov.—Stipites cæspitosi, graciles, 1½–2 pedes alti, pallide straminei, ad basin paleis ovato-lanceolatis albo-castaneis vestiti, superne nudi, nitidi, politi. Lamina subdeltoidea, 2–3-pinnata, 1½–3 pedes longa, 1–2 pedes lata, tenuiter membranacea, pallide virentia et nitentia, utrinque glabra, rhachi pallido. Pinnæ 4–12 poll. longæ, oblongo-lanceolatæ, acutæ vel acuminatæ; infimæ maximæ, inæquilateraliter oblongo-ovatæ, postice productæ. Pinnulæ anguste oblongæ, fere ad costam pinnatifidæ, segmentis lineari-oblongis vel obcuneatis, integris vel lobatis. Sori magni, subterminales. Indusium membranaceum, glabrum, pallidum.

Summit of Mount Tekou, alt. 1800 ft., rare and not seen elsewhere.

Apparently a well-marked species. Mr. C. H. Wright, of the Kew Herbarium, who has kindly examined my specimens, states that its nearest allies are *N. Milnei*, Hook., and *N. ferrugineum*, Baker.

Nephrodium decompositum, R. Br.—Ravines near the centre of the island, not common.

Fiji to Tahiti, New Zealand, Australia.

Nephrodium setigerum, Baker.—Not uncommon in the lower portions of the island.

New Hebrides to Tahiti, Australia, and northwards to Ceylon and Japan.

Nephrodium invisum, Carruth.—Abundant, especially on open hill-sides and in light forest.

Throughout the Pacific Islands.

NEPHRODIUM CUCULLATUM, Baker.—Native name *Opu-opu.* Common all through the island at low elevations.

Fiji to Tahiti, Malay Archipelago, India.

NEPHRODIUM HÆNKEANUM, Presl.—Native name *Opu-opu.* Lower portions of the island and valleys of the interior, not uncommon.

Fiji and Samoa to Tahiti, Malay Archipelago, Ceylon.

NEPHRODIUM MOLLE, Desv.—Apparently not common in Rarotonga. Near Ngatangiia; ravine at Papua.

Generally diffused in tropical and subtropical regions.

NEPHRODIUM (§ PLEOCNEMIA) LEUZEANUM, Hook.—Very abundant in the lower portions of the island, and very variable in size, from 1–6 ft.

Fiji, Samoa, Malay Archipelago, to India and China.

NEPHRODIUM (§ SAGENIA) DECURRENS, Baker.—Deep moist gullies towards the centre of the island, not uncommon.

New Hebrides to Tahiti, and northwards to India, Ceylon, and the Philippines.

NEPHROLEPIS ACUTA, Presl.—Native name *Turatou.* Most plentiful in all soils and situations, from sea-level to near 1000 ft.

Most warm countries.

NEPHROLEPIS RAMOSA, T. Moore.—Moist gullies towards the centre of the island, not uncommon. Climbs up trees to a considerable height.

Fiji and Samoa, Australia, tropical Asia and Africa.

POLYPODIUM (§ PHEGOPTERIS) UNIDENTATUM, Hook. & Arn.—Ascent of Mangatea, and dark gloomy places towards the centre of the island. I am indebted to Mr. C. H. Wright for this identification.

Sandwich Islands.

POLYPODIUM HOOKERI, Brack.—On trees, summit of Tekou, alt. 1800 ft., and slopes of Taitukura 1200–2000 ft.

Sandwich Islands, Tahiti, Fiji, Australia, Philippines.

POLYPODIUM (§ NIPHOBOLUS) ANGUSTATUM, Sw.—Common all through the island, on trees or rocks.

Pacific Islands, Australia, and northwards to India.

POLYPODIUM (§ PHYMATODES) PHYMATODES, Linn.—Very abundant in all soils and situations, from high-water mark to high up on the hills.

Most warm regions of the Old World.

POLYPODIUM (§ PHYMATODES) sp.—Summit of Taitukura, alt. 2200 ft. Rare and not seen elsewhere. Specimens too imperfect for proper determination.

POLYPODIUM (§ PHYMATODES) EXPANSUM, Baker.—Hills and valleys towards the centre of the island, plentiful in shady forests. Attains a height of from 3–5 ft.

Samoa to Tahiti.

MONOGRAMME JUNGHUHNII, Hook.—Head of a ravine near Ngatangiia, on trees; not seen elsewhere, but it is easily overlooked.

Pacific Islands and Australia northwards to Ceylon, Java, and the Philippines.

VITTARIA ELONGATA, Sw.—Abundant at the roots of trees on dry declivities up to 1500 ft.

Tropics of the Old World.

VITTARIA SCOLOPENDRINA, Thw.—Ravines at Ngatangiia, rare.

Samoa, New Guinea, Malay Archipelago to Ceylon and the Philippines, East Tropical Africa.

ACROSTICHUM SAMOENSE, Baker.—Slopes of Mount Taitukura, 1500–2200 ft.; not seen elsewhere.

Samoa.

ACROSTICHUM WILKESIANUM, Hook.—Valleys of the interior, not common. Often climbs trees to a considerable height.

Fiji to Tahiti.

ACROSTICHUM GORGONEUM, Kaulf.—Summit of Mount Tekou, 1800 ft.; slopes of Taitukura, 1500–2200 ft.

Sandwich Islands and Tahiti.

ACROSTICHUM REPANDUM, Blume.—Moist shady places in the interior, very abundant.

New Caledonia to Tahiti, Australia, and northwards to China and the Philippines.

ACROSTICHUM SPICATUM, Linn.—On trees and rocks in the interior of the island, most abundant.

Tropics of the Old World.

SCHIZÆA DICHOTOMA, Sw.—Dry declivities in the forests of the interior, common.

Widely distributed in the warm regions of both hemispheres.

ANGIOPTERIS EVECTA, Hoffm.—Native name *Anae*. Very abundant in the valleys of the interior, and attaining a large size.

Warm regions of the Old World.

Marattia fraxinea, Sw.—Native name *Para*. Valleys of the interior, not uncommon. The tuberous rootstocks were eaten by the natives in times of scarcity.

Many warm and some temperate regions.

Ophioglossum nudicaule, Linn. — Open places amongst patches of *Gleichenia dichotoma* on Maungaroa; not seen elsewhere.

Most warm regions.

Ophioglossum pendulum, Linn.—Apparently not common. Ravine at Papua; slopes of Maungaroa.

Pacific Islands, Australia, and northwards to Ceylon and the Philippines, Mauritius.

LYCOPODIACEÆ.

Lycopodium cernuum, Linn.—Dry hills, very common; usually intermixed with *Gleichenia dichotoma*.

Almost cosmopolitan in warm countries.

Lycopodium phlegmaria, Linn.—Not uncommon in the hilly portions of the island, pendulous from trees or rocks.

Tropics of the Old World.

Lycopodium squarrosum, Forst.—Rocky places on the mountains, not uncommon.

Pacific Islands and northwards to Malaya and India.

Psilotum triquetrum, Sw.—Very plentiful throughout the island.

All tropical regions.

Psilotum complanatum, Sw.—Plentiful, pendulous from trees.

Most tropical regions.

EXPLANATION OF THE PLATES.

PLATE 31.

Elæocarpus rarotongensis, Hemsl.

Fig. 1, sepal; 2, petal; 3, disc, stamens and pistil; 4, front view of anther; 5, side view of anther; 6, fruit with pericarp removed, natural size; 7, the same, magnified; 8, section of fruit; 9, section of seed; 10, embryo. All enlarged except 6.

PLATE 32.

Fitchia speciosa, Cheesem.

Fig. 1, bract of involucre (inner); 2, bract of receptacle; 3, floret; 4, anthers; 5, tip of style. All enlarged.

PLATE 33.

Sclerotheca viridiflora, Cheesem.

Fig. 1, section of flower; 2, section of staminal tube; 3, stigma. All enlarged.

PLATE 34.

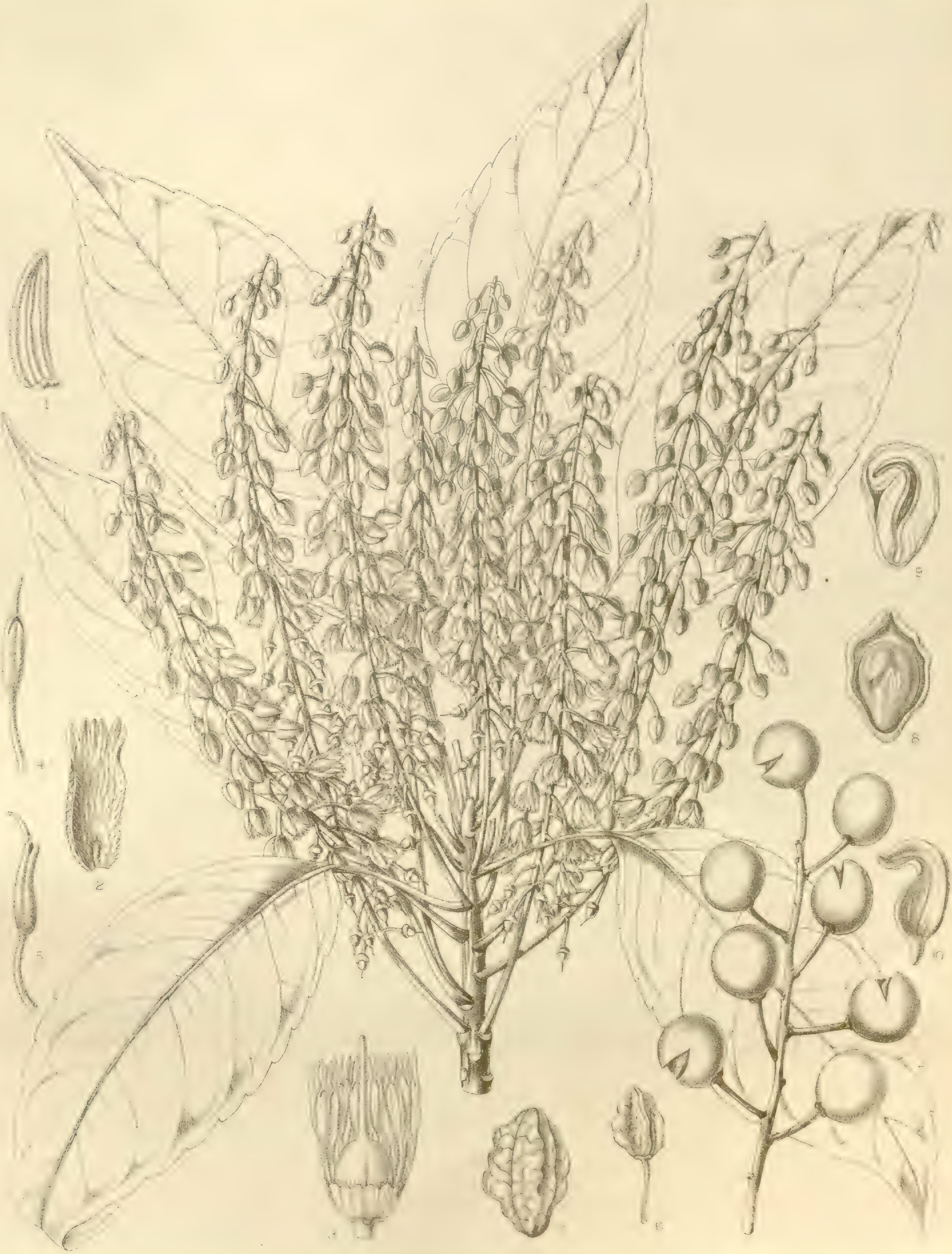
Myrsine Cheesemani, Hemsl.

Fig. 1, section of calyx with pistil; 2, corolla laid open; 3, 4, anthers; 5, fruit; 6, section of fruit. All enlarged.

PLATE 35.

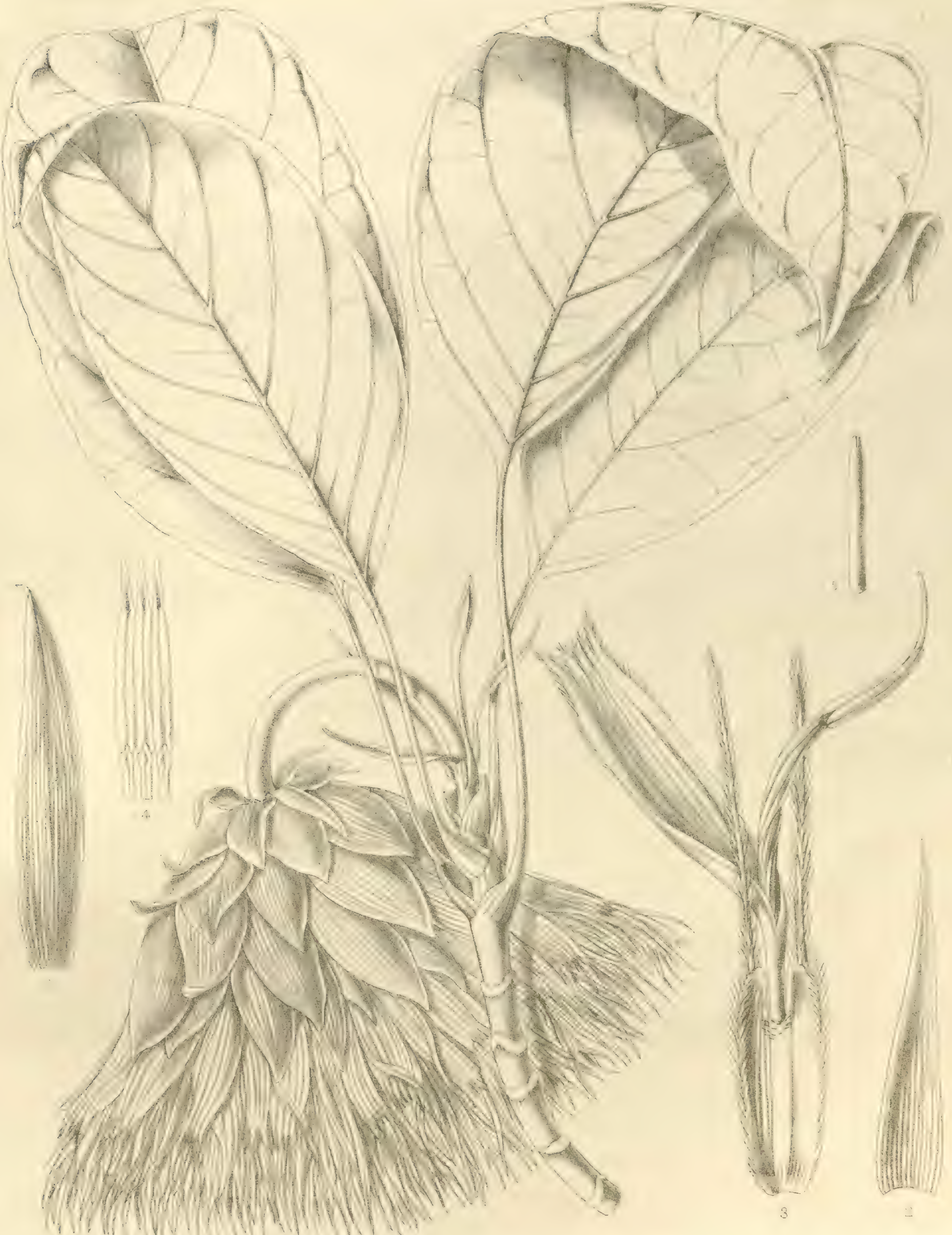
Cyrtandra rarotongensis, Cheesem.

Fig. 1, flower; 2, calyx with pistil; 3, corolla laid open; 4, petal and stamen. All enlarged.



M. Smith del., W. B. Hemsley dir.
J. N. Fitch lith.
West, Newman imp.

ELÆOCARPUS RAROTONGENSIS, *Hemsl.*



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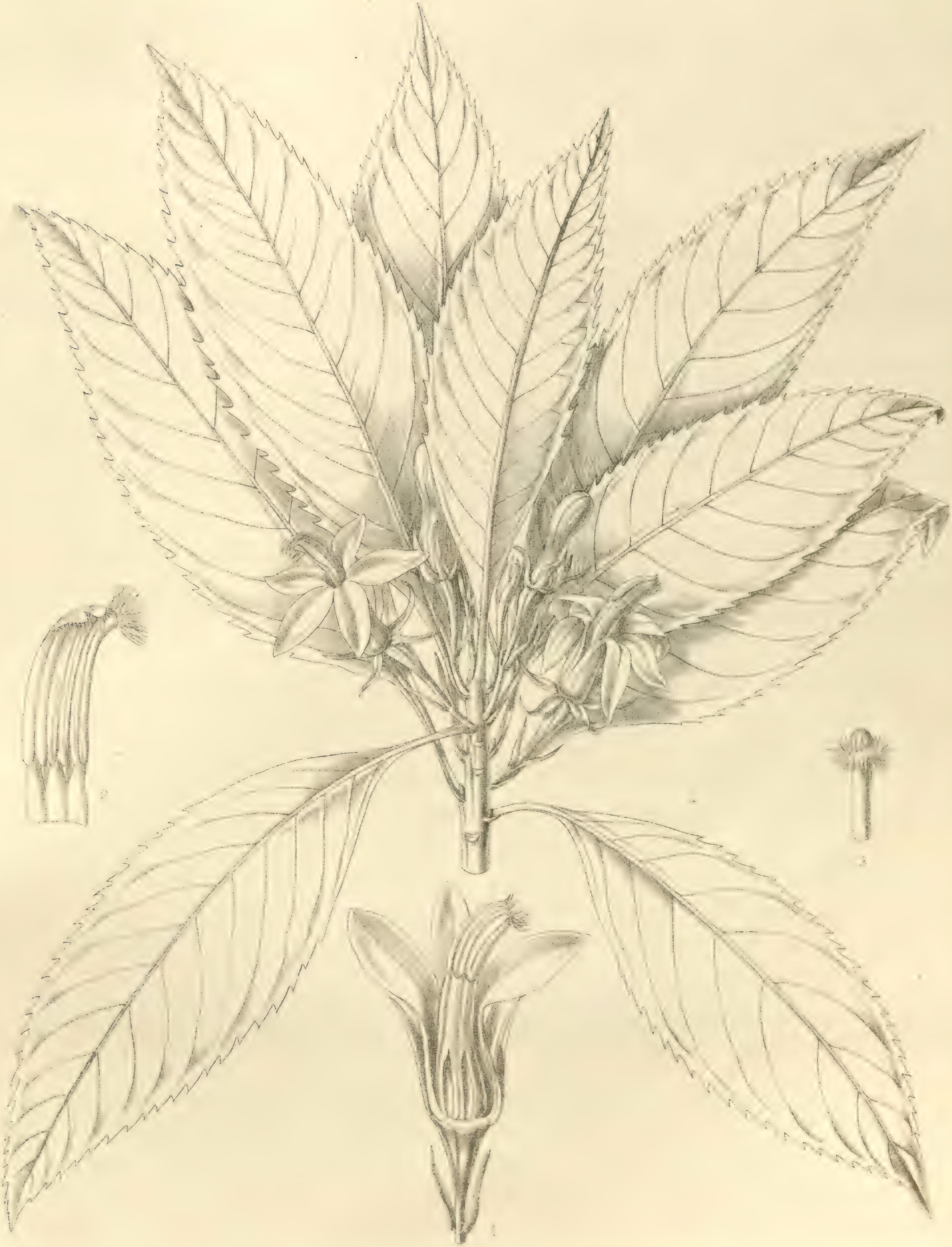
FITCHIA SPECIOSA, *Cheesem.*



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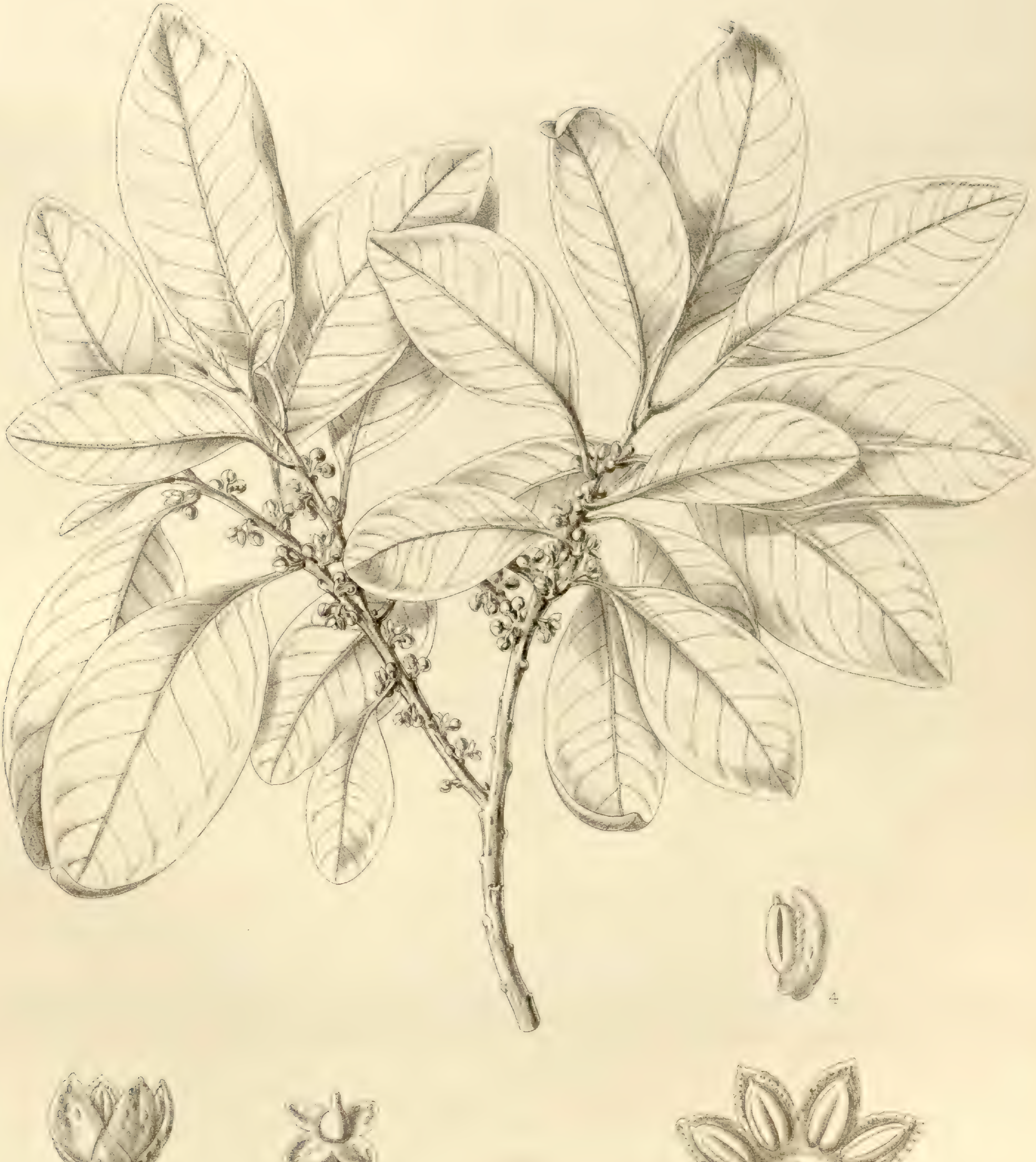
SCLEROTHECA VIRIDIFLORA, *Cheesem.*



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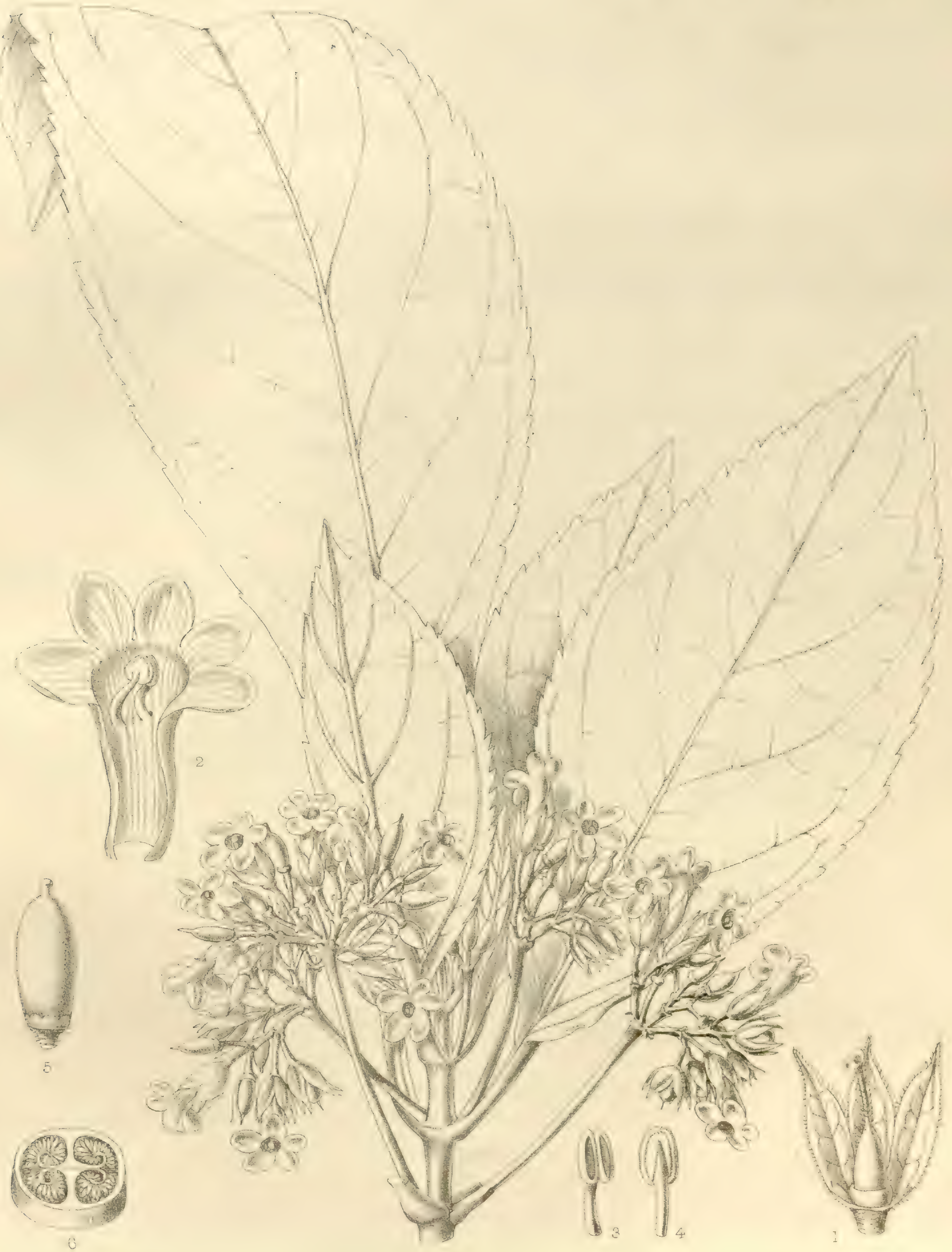
MYRSINE CHEESEMANI, *Hemsl.*

Trans. Linn. Soc. Lond. 2 Ser. Vol. VI. Pl. 35.



M. Smith del., W.B. Hemsley dir.

J.N. Fitch lith.
West, Newman imp.

CYRTANDRA RAROTONGENSIS. *Cheesem.*

LINNEAN SOCIETY OF LONDON.

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THE

TRANSACTIONS

OF

THE LINNEAN SOCIETY OF LONDON.

ON THE ANATOMY OF THE LEAVES OF BRITISH GRASSES.

BY

L. LEWTON-BRAIN, B.A., F.L.S.

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February 1904.

VII. *On the Anatomy of the Leaves of British Grasses.* *By* L. Lewton-Brain, *B.A.*, *F.L.S.*, *Hutchinson Student of St. John's College, Cambridge, and late University Demonstrator in Botany.*

(Plates **36-40.**)

Read 18th June, 1903.

Introduction.

Duval Jouve was the earliest investigator who undertook to give a general account of the structure of the leaves of grasses. In his first work (1870)[*] he described the general anatomy of the vegetative organs of grasses—root, rhizome, culm, and leaf. Later (1875) he published a paper dealing especially with the anatomy of the leaves. Güntz (1886) investigated the question of the influence of climate and habitat on the development of the mechanical tissue in the leaves of grasses. Schwendener (1889) gave an account of the structure of the stomata in the leaves of grasses and sedges, and later (1890) a detailed description of the stereome-sheath of the vascular bundles. A more complete account of this earlier work will be found in Pée-Laby's paper (1898).

Many workers, both botanists and agriculturalists, have recognized the fact that the anatomical structure of the leaves is a valuable aid in the identification of many of the grasses, especially when, as is the case during a great part of the year, one has only the vegetative organs to work with. Thus Stebler (1889), in his work on 'The Best Forage Plants,' gives a number of diagrammatic figures of transverse sections of the leaves of the grasses he describes.

MacAlpine (1890), too, in his book on grasses, uses certain points in the transverse section of the leaf as means of identification.

Pée-Laby (1898) also has in view the recognition of grasses from the anatomical structure of their leaves; thus he says: "I claim that in default of having flowering specimens sufficiently developed, this (*i. e.*, the transverse section of the leaf) would be the only means of correctly distinguishing very nearly related species." This statement, though to a great extent true, seems to me to be somewhat exaggerated, since an examination of the transverse sections of leaves of closely allied species of *Poa, Bromus, Aira,* and other genera will show that in many cases the anatomical structure of the leaves of nearly related species is very similar if not practically identical. This, as might be expected, is more especially the case when the species in question have a very similar habitat: when allied species have a dissimilar habitat, they very often have dissimilar leaf-structure; but it must be remembered that in these cases the grass may often be recognized without an examination of the leaf-section. Taking, for example, the four species of *Aira* that I have examined: *Aira caryophyllea* and *A. præcox* are ruderal grasses, *Aira flexuosa* is a heath-grass, and *A. cæspitosa* is found in moist and shaded places. The first two species are very similar in habit and cannot be separated, except when in flower; they are, however, easily distinguishable from *A. flexuosa* and from *A. cæspitosa*, as also these two species one from the other, merely by the general habit and the form and size of the leaves. Turning now to the anatomical structure of the leaves, we find that both *Aira cæspitosa* (Pl. **37.** fig. 20) and *A. flexuosa* (Pl. **36.** fig. 6) have very characteristic leaf-sections and are easily recognizable, but that the sections of *A. caryophyllea* and *A. præcox* (Pl. **36.** fig. 5) are practically identical, though very different from those of the former species. This is by no means an isolated case, and it is evident that we must not rely too much on the leaf-sections for separating closely allied species.

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[*] See Bibliography, *infrà*, p. 357.

Pée-Laby divides the grasses into five main groups, depending on the following characters seen in transverse section:—(1) Whether or not the upper and lower leaf-surfaces are parallel; (2) the relative number of stomata on the two sides; (3) the arrangement of the chlorophyll-tissue; (4) the degree of development of the motor cells. Thus his Group II. includes those grasses in which the leaves have the upper and lower surfaces not parallel, have a greater number of stomata on the upper face, have normal green parenchyma (*i. e.*, without large lacunæ and not arranged in rings around the bundles), and motor cells well developed. He claims that these groups include only grasses of similar biological characteristics; thus he says: "It [*i. e.*, the classification] will give an exact idea of their habitual situation, of their vegetative period, and to a certain extent of the soil which they require." This statement is, on the whole, correct, but, as will be seen later, it has numerous exceptions.

Raunkiær (1895–99) * in his account of the natural history of Gramineæ takes into consideration the anatomy of the leaves, and under each genus mentions the chief peculiarities of the leaf-structure. He also devotes a section to a connected account of "Leaf-formation," discussing the structure of the leaves from the point of view of the adaptations shown in relation to the environment, and more particularly to the conditions of water-supply and transpiration. He points out, however, and I think with justice, that some of the structural peculiarities of the leaves are not to be explained as being due to the influence of the environment. He says, for instance: "Naturally, we cannot explain all constructions directly by a consideration of the outer factors, though many can be explained, or at least understood, in this way. Others, which are of a more primitive phylogenetic nature, are outside the laws of adaptation." He gives a number of diagrammatic figures of transverse sections of the leaves.

Professor Marshall Ward (1901), in his recent book on 'Grasses,' devotes two chapters to the leaf-structure. In Chapter IV. he gives a fairly complete, though necessarily somewhat short, account of the chief anatomical and histological features of the leaves with some reference to their biological importance; and in Chapter V. a classification of the more common grasses based on the anatomical characters of the leaf. The form of classification adopted is that of a continuously dichotomizing key. The main characters made use of are, as with Pée-Laby, the arrangement of the chlorophyll-tissue, the presence or absence of conspicuous ribs on the upperside of the leaf, the relative number of stomata on the two sides, and the position and arrangement of the motor cells. Other characters made use of are the degree of development and the arrangement of the mechanical tissue and the hairiness. He claims, however, only to have "brought together some of the principal anatomical features in such form that their characters may be employed in checking other determinations of grass-leaves."

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* I am indebted to Professor Bayley Balfour for a translation of those parts of Raunkiær's work which bear on the present research.

My own acquaintance with the subject began by my testing, at Professor Marshall Ward's request, his classification of leaf-sections. The object of the present research has been twofold. In the first place, I hoped that, by accurate diagrams and short descriptions of a number of transverse sections of the leaves, some further help might be given towards identifying grasses from their vegetative characters. In the second place, I wished, after placing the grasses in groups according to habitat, to see how far in each case the structure of the leaves is adapted to the environment.

In Pée-Laby's work, the leaves used were taken from plants growing in the Botanical Gardens at Toulouse, and which had either been raised from seed or had been planted there for a long time. This plan is open to the obvious objection that cultivation in a soil differing from that of their natural habitat, and otherwise under unnatural conditions, may very possibly influence the growth of the plants, so that the structure of leaves taken from such plants may be obviously different from the normal one. I had hoped to make some experiments to discover what changes, if any, are produced in the structure of the leaf by alterations in the environment. The leaves for my own work were in nearly every case taken from plants growing under natural conditions in their natural habitat; in one or two cases only, where I have been unable to obtain such leaves, have I made use of cultivated plants.

The leaves were fixed in absolute alcohol and sections cut by hand. The diagrams were all drawn by means of a camera lucida, thus securing identity of magnification and rendering comparison more easy.

I propose to divide the remainder of this paper into three parts:—

I. A short account of the general anatomy and histology of grass-leaves, so far as is necessary to explain the following parts (II. & III.).

II. Brief descriptions of the leaf-structure of all the grasses I have examined, arranged in an artificial key for purposes of classification.

III. A grouping of the grasses according to habitat, and a discussion of the question how far a similarity in environment entails a similarity in leaf-structure.

PART I.—GENERAL ANATOMY AND HISTOLOGY.

GENERAL ANATOMY.

The form of the grass-leaf as seen in transverse section is extremely variable. We may recognize four main types, not one of which is sharply marked off from the others, but all are connected by numerous transitional forms.

1. Leaves in which the upper surface is either flat or practically so. Examples of leaves with a perfectly flat upper surface are most species of *Poa, Glyceria* (Pl. **38.** figs. 37, 39), *Avena pratensis* (Pl. **37.** fig. 28), *Triodia decumbens* (Pl. **38.** fig. 34), &c. Among those in which the upperside shows ribs that are practically obsolete may be mentioned *Arrhenatherum avenaceum, Phleum pratense* (Pl. **39.** fig. 46), *Brachypodium sylvaticum,* different species of *Bromus, Melica uniflora,* and *M. nutans.*

This type is said by Raunkiær to be " only found in marsh- and wood-grasses, and in certain 'mark' and meadow-grasses." This remark is true so far that, as will be seen later, most (though not all) wood and aquatic grasses possess this type of leaf; but included in this group we have also not only many meadow-grasses, but several grasses characteristic of waste places as well, e. g. *Bromus sterilis* (Pl. **37.** fig. 27), *Agropyrum repens, Setaria viridis* (Pl. **38.** fig. 36), *Hordeum murinum,* and others; heath-grasses, such as *Triodia decumbens* (Pl. **38.** fig. 34); maritime grasses, such as *Poa bulbosa* (Pl. **39.** fig. 47) and *Cynosurus echinatus* (Pl. **39.** fig. 51); and even alpine grasses, such as *Phleum alpinum* (Pl. **39.** fig. 52). In fact all the biological groups have their representatives here. This point alone shows the extreme difficulty of making any generalizations on this subject.

The stomata in this type of leaf are usually distributed on both surfaces.

2. Leaves in which the upper surface is marked by distinct, though not very high, ribs.

As examples of grasses with this type of leaf may be mentioned *Lolium perenne, Alopecurus pratensis* (Pl. **37.** fig. 18), and *Festuca pratensis* among meadow-grasses; *Festuca Myuros, Poa rigida* (Pl. **37.** fig. 23), and *Alopecurus agrestis* among vagabond-grasses; *Alopecurus geniculatus* (Pl. **37.** fig. 21) among aquatic grasses; *Phleum arenarium* and *Poa loliacea* among maritime grasses; and *Agrostis canina* (Pl. **37.** fig. 19) among heath-grasses.

This type of leaf is of a slightly more xerophytic character than the last one. Thus we get included here only one aquatic grass and no wood-grasses. The stomata are usually most abundant on the flanks of the ribs, and are thus more or less sheltered. Most of the grasses belonging to this series are meadow and wayside plants; they are exposed at times to fairly strong transpiration, but, on the whole, live under moderately favourable conditions as regards water-supply. The great majority of the two largest groups of grasses—from meadow and from waste places—possess leaves either of this type or of the preceding one, or are intermediate between the two. It is impossible to draw any hard-and-fast line between the two forms of leaf, the number of intermediate forms being even greater than that of the typical ones.

3. Leaves in which the upper surface is marked by very distinct and high ridges.

Not many grasses possess leaves of this type, but as examples I may mention *Psamma arenaria* (Pl. **36.** fig. 12), *Agropyrum junceum* (Pl. **36.** fig. 13), and *Aira cæspitosa* (Pl. **37.** fig. 20).

Raunkiær describes the type as "strongly xerophilous," and says that it is found "in grasses on dry sunny spots, where the outer conditions for very strong transpiration are sometimes present, but the conditions for water-supply from the earth are very unfavourable." This is very true if we exclude *Aira cæspitosa*, which is found in moist shaded meadows, that is, under conditions where transpiration is always small and where the water-supply is abundant, thus giving us another example of the difficulty of generalizing. Excluding *Aira cæspitosa*, the grasses with leaves of this type are markedly xerophytic, and all are maritime grasses. The stomata are confined entirely to the upper surface and to the flanks of the ridges; thus even when the leaves are unrolled transpiration cannot be very great, and when they are rolled, as is always the case in hot weather, it will be reduced to a minimum. It must be pointed out, however, that these high ridges considerably increase the surface-area of the upperside of the leaf, and consequently allow of the development of a larger number of lines of stomata; thus Pée-Laby says that in *Aira cæspitosa* the number of lines is increased fourfold by the development of these high ridges. It may be that in the development of a large number of stomata, the broad grooves between the ridges, and the absence of any considerable number of hairs which would prevent a free passage of air between the ridge, we have the explanation of the leaf-structure of *Aira cæspitosa*.

In most of the leaves of this type the stomata are confined to the upper surface—to the flanks of the ridges.

4. Leaves in which the upper surface is reduced to a mere fold in the almost solid leaf.

This type is seen at its highest development in the leaves of *Aira flexuosa* (Pl. **36.** fig. 6); other examples of it are *Nardus stricta* (Pl. **36.** fig. 2) and *Festuca ovina* (Pl. **36.** figs. 3, 4). Also to a certain extent we may include the leaves of some varieties of *Festuca duriuscula* (Pl. **37.** fig. 17), and the lower leaves of the heterophyllous variety of *Festuca rubra* (Pl. **36.** fig. 7).

This form of leaf is highly specialized and strongly xerophytic. The grasses with leaves belonging here are all more or less heath-grasses, growing in dry wind-swept localities, where, although the water-supply may not be excessively small, the transpiration is exceedingly strong. The stomata are confined to the small, well-sheltered, upper surface.

Leaves of this type are probably derived phylogenetically from leaves of our second type. This is well shown in the various subspecies and varieties of *Festuca ovina*. The flat upper leaves of *Festuca rubra* and those of some specimens of *F. duriuscula* (Pl. **37.** fig. 17) belong clearly to the second type. In the lower leaves of the heterophyllous *F. rubra* (Pl. **36.** fig. 7), and in those of some specimens of *F. ovina* (Pl. **36.** fig. 3), the midrib has become comparatively more important and larger, while the lateral ribs are fewer and, proportionately to the midrib, smaller, though still obvious, and the leaf is generally folded. Finally, in the typical *F. ovina* (Pl. **36.** fig. 4) the midrib forms the greater part of the leaf, the other ribs have disappeared, and the whole of the lateral parts of the leaf have become mere appendages of the midrib. By a still further increase of the midrib and an even greater reduction of the lateral parts, we should arrive at the type met with in *Aira flexuosa.*

Perhaps one ought to describe the extremely small leaves of such grasses as *Mibora verna* (Pl. **36.** fig. 1), *Aira caryophyllea, Aira præcox* (Pl. **36.** fig. 5), &c. as a fifth type. These grasses are generally annuals, with a short vegetative period, and are characteristic of dry exposed situations. The leaves are very short and narrow, and their structure is extremely reduced.

HISTOLOGY.

Epidermis.—The epidermis is, as might be expected, the most variable of the tissues of grass-leaves. Under this heading, we have to consider not only the ordinary cells of the epidermis, but also the motor cells, hairs and other emergencies, and the stomata.

The epidermal cells generally appear more or less square in transverse section (Pl. **40.** figs. 53–56); in longitudinal section they appear as enormously elongated rectangles (Pl. **40.** fig. 74), the long axis being thus parallel to the long axis of the leaf. Occasionally we get interspersed among these long cells short cells of various forms. The cells, as is well known, are arranged in rows, running along the long axis of the leaf.

Grob (1896) has worked out the histology of the epidermis of grass-leaves pretty thoroughly, though unfortunately he is not concerned with many of the British species.

The form of the outer wall of the epidermal cell varies considerably. Most generally, perhaps, it is slightly arched outwards (Pl. **40.** figs. 53, 55, 73). A common feature is for the upper epidermal cells to be arched, while those of the lower epidermis are much flatter (Pl. **40.** figs. 53–56); the lower epidermis is also commonly more strongly cuticularized than the upper. These features are, of course, best seen in the xerophytic grasses, e. g. *Triodia decumbens* (Pl. **40.** figs, 58, 59), but are also well marked in many other grasses, *Hierochloë borealis* (Pl. **40.** fig. 66), *Lolium temulentum* (Pl. **40.** figs. 55, 56), *Festuca duriuscula* (Pl. **40.** fig. 62), &c. Another fairly common feature is for the epidermal cells which adjoin the bands of mechanical tissue to become smaller and to have thicker walls than the remaining cells (Pl. **40.** figs. 62, 72); in fact they take on the appearance of sclerenchyma-cells, and generally the outer wall is much thicker than the others. The arching outwards of the outer wall of the epidermal cell is sometimes much exaggerated, and the cell in fact becomes papillose, as is well seen, for example, in the cells of the upper epidermis of *Glyceria fluitans* (Pl. **40.** fig. 63); in *Mibora verna* again (Pl. **40.** figs. 60, 61) the cells of both the upper and the lower epidermis are much arched, and are, moreover, very feebly cuticularized. These features are in harmony with the general feebleness of the tissues of this leaf, and depend upon its extreme smallness.

Mention must also be made of the very exceptional epidermal cells of *Setaria viridis* (Pl. **40.** fig. 65), which are most unusually large—each cell, in fact, forms from one-fourth to one-third of the thickness of the leaf. I cannot understand the function of these large cells. It has been suggested to me that they serve for water-storage; but this is, I think, negatived by their position, and by the fact that neither epidermis is at all strongly cuticularized; moreover, they do not correspond to the position of the water-storing tissue which is found in certain Egyptian desert-grasses and described by Volkens (1887).

The "motor cells" serve the function of bringing about the folding or rolling which takes place in nearly all grass-leaves in dry weather, and serves to protect the upper surface of the leaf against excessive transpiration. When the leaf is folded or rolled, only the lower surface (or part of it) is exposed, and this, as has been seen above, generally possesses a stronger cuticle, fewer stomata, &c. than the upper, and is thus less liable to excessive transpiration under dry conditions. The change is probably brought about by an alteration in turgidity of the motor cells, causing them to contract and thus shortening the upper surface of the leaf. Kerner *, however, considers that in some cases, at least, these "motor cells" are not strong enough for this purpose, and suggests that the change is brought about by the swelling of certain thick-walled cells situated under the lower epidermis. This to me seems hardly satisfactory. He also suggests that the "motor cells" function as a kind of pneumatic cushion during the folding of the leaf, and also, in part at least, as water-absorbing cells, a view which seems to be based on an exaggerated idea of the feebleness of the cuticularization of their outer walls (Pl. **40.** figs. 57, 75).

The motor cells differ from the ordinary epidermal cells chiefly in their greater depth (Pl. **40.** fig. 57, 75). They are much more narrowed at their outer than at their inner end, where they touch the assimilating parenchyma. They pass gradually into the ordinary cells of the epidermis, and are sometimes hardly distinguishable from them; in other cases, however, as in most species of *Poa*, in *Triodia decumbens* (Pl. **40.** fig. 59), *Arundo Phragmites*, *Hierochloë borealis* (Pl. **40.** fig. 66), &c., the difference is very marked. The cells are certainly not conspicuously more thin-walled than the ordinary cells of the epidermis (Pl. **40.** figs. 55, 57).

The motor cells are arranged in bands running longitudinally along the whole length of the leaf. In leaves where the upper surface is more or less ribbed a band of motor cells is generally found at the base of each groove (Pl. **37.** fig. 17; Pl. **39.** fig. 50, &c.). Where the upper surface is perfectly smooth we usually find two bands of motor cells, one on each side of the midrib. This is the case, for instance, in most species of *Poa*, *Glyceria* (Pl. **38.** figs. 37, 39), *Catabrosa aquatica* (Pl. **38.** fig. 38). In *Dactylis glomerata*, alone among British grasses, there is only one band of motor cells, and it stretches right across the midrib (Pl. **38.** fig. 31).

Long silky hairs are not common on grass-leaves. They do occur, however, in certain roadside grasses, as in *Holcus lanatus* (Pl. **39.** fig. 43), *H. mollis* (fig. 42), *Bromus sterilis* (Pl. **37.** fig. 27), &c., and there can be little doubt that here they serve to prevent excessive transpiration by retaining a layer of more or less water-saturated air about the leaves. They may serve also in preventing the stomata, &c. being blocked by dust, a danger to which these roadside grasses are peculiarly liable in dry weather.

Much more common are shorter, stiffer hairs; but these vary considerably in abundance and arrangement, also probably in function. In xerophilous grasses, both of the heath and maritime types, they are usually absent from the lower side of the leaf, but are very abundant above. This is well seen, for example, in *Agropyrum junceum* (Pl. **36.** fig. 13) among maritime, and *Aira flexuosa* (Pl. **36.** fig. 6) among heath-grasses. In this case also they doubtless serve to hinder excessive transpiration by preventing a free circulation of air in the groove, or grooves, the sides of which represent the transpiring surface in these grasses.

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* Kerner, 'Natural History of Plants,' Engl. ed. (1897), pp. 339–345.

In most grasses where these hairs are found, however, they are much less abundant than this, and can then hardly serve for the purpose of reducing transpiration. Sometimes they occur more or less in connection with the bands of stereome, more commonly at the summits of the ridges, less often also below the bundles in the lower epidermis. As examples, I may mention *Agrostis Spica-venti* (Pl. **37.** fig. 22) and *Festuca bromoides.* Often, however, the hairs are simply scattered irregularly over one or both surfaces of the leaf, as in *Poa trivialis*, *Cynosurus cristatus*, &c.

Even more common are short stiff emergencies, or asperities, which can hardly be termed hairs; they are often abundant on the margins of the leaves, but are also found scattered on both surfaces.

Mention must also be made of the short, blunt hairs found in the upper epidermis of *Nardus stricta* (Pl. **36.** fig. 2; Pl. **40.** fig. 64). They are very characteristic, and are similar in appearance to the papillæ mentioned above in the upper epidermis of *Glyceria fluitans.*

The hairiness of the leaves of any particular grass varies considerably, and can rarely be relied on as a distinctive character.

The stomata of grass-leaves do not present any peculiarities of structure. In nearly every case the stoma possesses only two guard-cells, and is flush, or nearly so, with the surface (Pl. **40.** figs. 58, 66, 73). They are arranged, as is well known, in longitudinal rows along the leaf, interspersed among the long epidermal cells. We usually find two or three rows of stomata close together, and next these several rows of long cells without stomata.

The protection of the stomata in grass-leaves then is not secured by their structure, but by their position and arrangement. In strongly xerophytic grasses, stomata are entirely absent from the lower epidermis; they are confined to the upperside, which is the one protected by the rolling or closing up of the leaf. In the majority of grasses the stomata are more abundant on the upper surface than on the lower, but we get all stages between an equal number on both sides and an entire absence from the lower side.

Vascular Bundles.—The vascular bundles enter the leaf separately and run parallel from base to apex of the blade. Minute cross-anastomoses between the parallel veins are not infrequent and are often seen in transverse section.

Pée-Laby recognizes five orders of vascular bundles, distinguished by the characters of the xylem as follows:—

The bundles of the *first* order are of the normal monocotyledonous type, with two large pitted or reticulate vessels and a large intercellular space, representing the position of the protoxylem.

The bundles of the *second* order possess the two large lateral vessels, but no intercellular space.

The bundles of the *third* order possess neither intercellular nor lateral vessels.

The bundles of the *fourth* order are similar to the preceding, but have a smaller amount of lignified tissue.

The bundles of the *fifth* order possess no lignified elements.

I have never seen a bundle of the fifth order. Moreover, the distinction between bundles of the third and fourth orders is so slight that it is practically useless to continue to recognize it.

I have, therefore, only recognized three orders of bundles. Pl. 40. fig. 69 shows a bundle of the *first* order from the leaf of *Festuca pratensis*; fig. 70 one of the *second* order from the leaf of *Elymus arenarius*; fig. 71 one of the *third* order from the leaf of *Agropyrum repens*. In a leaf-section of *Agropyrum junceum* bundles of all three orders can easily be recognized with the aid of a pocket-lens.

Nearly all grass-leaves possess vascular bundles of each of the three orders. The character is, therefore, not of importance in recognizing the leaves in transverse section, and I have not thought it necessary to indicate the different orders in the diagrams—no further, at least, than can be made out from their relative sizes.

The bundles, whatever their size, always show both xylem and phloem elements. The proportion of fibrous elements varies very largely—in *Molinia cærulea*, for instance, they form the greater part of the bundle.

When a leaf is ribbed, we nearly always get one vascular bundle in the centre of each rib. In the enormous triangular ribs of *Aira cæspitosa* (Pl. 37. fig. 20) we get one or more subsidiary bundles in addition to a large one in each rib. In *Glyceria fluitans*, again (Pl. 38. fig. 39), we get a number of low ribs on the upperside, but the vascular bundles are situated in the thinner parts of the leaf between the ribs, the centre of the rib being occupied by a large air-space.

For leaves where the midrib projects strongly below, the central bundle of the leaf is often much larger than any of the others; this is the case in most species of *Poa*, in *Arrhenatherum avenaceum*, &c. Very often, however, this central bundle is no more conspicuous than the other large bundles of the leaf.

Bundle-sheaths.—In nearly all leaf-sections each bundle is seen to possess two or more conspicuous sheaths, each one cell thick, surrounding it.

The inner sheath (Pl. 40. figs. 69–71, *i.s.*) is always more or less thick-walled and lignified. Pée-Laby states (on what evidence I do not know) that it represents the endodermis. It is usually more conspicuous in bundles of the *first* and *second* than in those of the *third* order, where, indeed, it sometimes can hardly be recognized (fig. 71).

Raunkier notes that in the small bundles of many grasses the inner sheath is only partial, surrounding the phloem, but not the xylem. Generally, the inner walls of the cells are much more strongly thickened than the outer, the radial walls in part sharing the thickening (Pl. 40. fig. 69); the thick inner wall is in these cases provided with numerous pits. Sometimes, however, the cell-wall is equally thickened all round (Pl. 40. fig. 70). In cases where the bundle is joined to the epidermis by a sclerenchyma-band, the inner sheath becomes continuous with the tissue of the girder (figs. 69–71).

The function of this thick-walled sheath is probably, as suggested by Raunkiær, that of mechanical protection to the bundle, and more particularly to the soft-walled phloem.

Great stress is laid by Pée-Laby upon the outer sheath to the vascular bundles. This is thin-walled, and in transverse section differs from the ordinary parenchyma of the leaf only in the arrangement of its cells around the bundle, and sometimes in their smaller size (Pl. 40. fig. 70, *o.s.*). In longitudinal section it is easily distinguishable, the cells being much elongated in the direction of the long axis of the leaf.

Like the inner sheath, this thin-walled sheath is usually more easily recognizable in bundles of the *first* and *second* than in those of the *third* order (compare fig. 70 with fig. 71). This is due, in part, to the fact that in these large bundles the cells lose their chlorophyll and become colourless, while in the small bundles they are usually green; sometimes also round these small bundles the cells of the outer sheath are less regularly arranged, and are thus hardly distinguishable from the surrounding green parenchyma in transverse section (fig. 71). Sometimes, again, the outer sheath is quite conspicuous round the small bundles—this is particularly the case in *Setaria viridis*, for example (fig. 65).

From its position and the arrangement of its cells it would appear probable that this outer sheath functions as transfusion-tissue, placing the bundles in more intimate connection with the assimilating green parenchyma.

Mechanical Tissue.—The amount of mechanical tissue present in the leaves of grasses varies within very wide limits. In the small leaves of *Mibora verna* (Pl. 36. fig. 1), &c., it is practically absent; while in the leaves of the maritime sand-grasses, for instance, it is present in greater amount than any other tissue (Pl. 36. fig. 12 of *Psamma arenaria*, and Pl. 36. fig. 9 of the tip of the leaf of *Elymus arenarius*).

The form of the elements of the mechanical tissue is that of De Bary's * sclerenchyma-fibres—that is, much elongated, thick-walled, empty cells with pointed ends (*Psamma arenaria*).

The stereome is arranged in bands running longitudinally the whole length of the leaf. The most usual positions for these bands is just within the epidermis above and below the vascular bundles (Pl. 39. fig. 41 &c., and Pl. 40. fig. 62, *st.*) and always at the margin of the leaf (Pl. 38. figs. 33, 34, &c., and Pl. 40. fig. 68, *st.*). Very frequently the bands above and below the vascular bundles extend right to the bundles piercing the outer sheath; they become continuous with the inner thick-walled sheath, and thus form girders to the bundles, joining these to the lower or upper epidermis (Pl. 36. fig. 14, Pl. 38. fig. 34, and Pl. 40. fig. 70, *st.*). Another common feature is for the stereome on the lower side of the leaf to be stronger than that on the upper; thus we often find bundles girded only to the lower epidermis, and with only a small band of stereome above. In many grasses, on the other hand, the stereome is about equal on the two sides, or it may even be slightly stronger on the upper (Pl. 38. fig. 37; Pl. 39. fig. 45). The tendency for the mechanical tissue to be stronger on the lower than on the upper side is much accentuated in some maritime and heath-grasses—for example, *Psamma arenaria* (Pl. 36. fig. 12) and *Festuca ovina* (Pl. 36. fig. 3),—the reason for which we shall consider later.

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* De Bary (1884), pp. 128 &c.

Sometimes the bands of stereome under the lower epidermis broaden out laterally and may even become united with one another, thus forming a continuous band of sclerenchyma under the lower epidermis. This is seen, for example, in the maritime grasses *Psamma arenaria* (Pl. **36.** fig. 12) and *Agropyrum junceum* (Pl. **36.** fig. 13) and in some varieties of *Festuca ovina* (Pl. **36.** fig. 4).

Occasionally we find supernumerary bands of stereome. Thus in *Aira cæspitosa* (Pl. **37.** fig. 20, and Pl. **40.** fig. 67, *st.*), *Alopecurus geniculatus* (Pl. **37.** fig. 21), and a few other grasses we find bands on the lower side opposite the bottoms of the grooves. In these cases the leaf between the ribs is usually thin, and the extra bands are therefore necessary for support. Again, in *Aira flexuosa* (Pl. **36.** fig. 6) the mechanical system is represented on the lower (outer) side of the leaf by a large number of very small stereome-bands, arranged very close together without any reference to the vascular bundles. Then also in *Glyceria aquatica* (Pl. **38.** fig. 37) we find, in addition to the girders to the vascular bundles, numerous small bands under both upper and lower epidermis; these probably function in supporting the leaf, which is much weakened between the bundles by the development of the large air-lacunæ.

The primary function of the mechanical tissue is, of course, that of support, and the arrangement of bands and girders found in grass-leaves is that best calculated to afford support to these long, linear, bilateral structures, as Haberlandt * has shown.

The extreme abundance of mechanical tissue in some maritime grasses seems, however, to drive Raunkiær to seek for other functions for the stereome. Thus he speaks of the strengthening tissue of *Psamma arenaria* and *Agropyrum junceum* "serving as a protection against evaporation." He also suggests that the strengthening tissue may serve for water-storage. He makes mention also of a rule "that the strengthening tissue increases in massiveness and in firmness in proportion as the moisture of the soil decreases and the conditions for transpiration increase."

In the first place, I question very much whether this rule holds good in grass-leaves. The heath-grasses are perhaps even more specialized for xerophytic conditions than those of maritime sands, but here we certainly do not find any excessive development of mechanical tissue; in *Aira flexuosa* (Pl. **36.** fig. 6) indeed, the most highly specialized of the group, the amount of strengthening tissue is relatively very small. Then, again, in certain water-grasses, as *Arundo Phragmites* (Pl. **39.** fig. 49), the stereome is strong and abundant.

Again, when we consider the strength of the lower epidermis of *Agropyrum junceum* and *Psamma arenaria*, the great cutinization and the flatness of the outer walls of its cells, and the entire absence of stomata from the lower side of the leaf, it would appear doubtful whether the presence of a subepidermal band of lignified cells would materially reduce the transpiration.

It seems, therefore, to me most probable that the sole function of the stereome is that of support, and that we can explain its variations entirely from this point of view.

The leaves of the heath-grasses are subulate and narrow; their mechanical tissue is therefore comparatively small in amount, and, as is typically the case in cylindrical organs, it is arranged in bands just within the outer epidermis. This is particularly well seen in *Aira flexuosa* (Pl. **36.** fig. 6), where the small bands under the lower epidermis with the marginal bands and the band at the summit of the single ridge on the upperside form an almost complete hollow cylinder of mechanical tissue.

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* Haberlandt (1896), pp. 156 &c.

The reed-grasses, again, have broad leaves, and on account of their tall stems the leaves are exposed to winds more than is usual in water-grasses. Accordingly we find the mechanical tissue unusually well developed.

Again, the maritime sand-grasses are constantly exposed to terrific storms and winds, and we should naturally expect, on this account, an exceptional development of the mechanical tissue. But we might also expect these exceptional strains to be met simply by a stronger development of the system of girders and marginal bands, as is actually the case in *Elymus arenarius*. We have also to explain the presence of the subepidermal bands in *Psamma arenaria* and *Agropyrum junceum*. We must remember that under dry conditions the leaves of these grasses are rolled up, and that dry conditions are very frequent for them. Thus, during a greater part of their life, these leaves are not bilateral, but cylindrical organs, and the subepidermal band is thus the mechanically best arrangement of the stereome, forming as it does a hollow cylinder of strengthening tissue at the periphery of the organ.

I have already mentioned Kerner's suggestion that these subepidermal bands of thick-walled cells aid in the rolling up of the leaf.

Chlorophyll-containing Tissue.—In the great majority of grass-leaves the chlorophyll-tissue appears in transverse section to be composed simply of a mass of closely packed, irregularly shaped, but more or less isodiametrical, cells with small intercellular spaces (Pl. **40.** figs. 58, 67, 73, *mes.*).

In longitudinal section, however, the arrangement of the chlorophyll-cells is seen to be a much more definite one (figs. 74, 75, &c.). Under the upper epidermis we find a regularly arranged layer of cells (fig. 74, $p.^1$), which, by reason of its position, the arrangement of its cells, and probably its function, invites comparison with the palisade-tissue of the leaves of Dicotyledons; the cells are, however, nearly isodiametric. Under the lower epidermis we get a very similar palisade-layer (figs. 74, 75, $p.^2$). Then, stretching from the upper palisade-layer to the lower, we get branched chains of cells (figs. 74, 75) with much larger air-spaces. These chains, where they would be broken by a vascular bundle, become attached to the outer bundle-sheath. These features are much more striking in some cases than in others, but in the small number of leaves that I have examined they can always be made out. A more complete examination of the assimilating tissue of grass-leaves would probably bring to light many interesting facts. Occasionally the cells both of the "palisade" and "spongy" mesophyll have very curious shapes, and further investigation would probably show that this is common.

A much more exceptional form of assimilating tissue is met with in a few British grasses, as *Poa rigida* and *Setaria viridis*. In these leaves the assimilating tissue is arranged in rings around the vascular bundles (Pl. **40.** figs. 65 & 72). These grasses are all more or less xerophytic in habitat, and the arrangement of the chlorophyll-cells in rings, which according to Volkens is also found in Egyptian desert grass-leaves, is probably an adaptation to the xerophytic mode of life. It would seem to tend to facilitate the distribution of the water-supply brought up by the vascular bundles.

In certain aquatic grasses, as in *Glyceria fluitans* (Pl. **38.** fig. 39) and *G. aquatica* (fig. 37), and in *Molinia cærulea* (fig. 29), the assimilating tissue is broken up by the development of large air-lacunæ. These doubtless serve for the better aeration of the assimilating cells.

Not uncommonly, when the vascular bundle is not girdered on one side but has a band of stereome above (or below) it, the assimilating tissue is broken by a band of thin-walled colourless cells stretching from the outer sheath of the bundle to the band of stereome (Pl. **37.** figs. 24, 28; Pl. **39.** fig. 49).

PART II.—THE STRUCTURE OF THE LEAVES OF THE GRASSES EXAMINED.

I. Leaf-section rounded, angular, or curved, not much broader than deep. Vascular bundles few and feeble, as are also the stomata and motor cells.

A. Sections cordate or shield-shaped, with a channel above—*i. e.*, subulate or permanently infolded leaves.

a. No stereome apart from the three vascular bundles. Motor cells and hairs obsolete. Stomata chiefly on upper surface. Epidermal cells feebly chitinized and arched.

MIBORA VERNA (Pl. **36.** fig. 1). Anglesey. April 1902.

Leaf very small. Midrib slightly marked. Three small vascular bundles all of third order. All have double sheath, but inner one is not strongly thickened.

b. Extra-fascicular stereome developed. Motor cells in the grooves. Stomata and hairs on upper surface only. Lower epidermal cells strongly cutinized, upper much less so.

i. Girders to some or all of the 5–7 vascular bundles. Numerous short blunt hairs above.

NARDUS STRICTA (Pl. **36.** fig. 2). Scearning Fen, Norfolk. June 1901.

Section roughly circular in outline. Upperside with well-marked ribs and grooves, covered with numerous, short, blunt hairs. Vascular bundles few, of first and third orders. All with both sheaths well marked. Stereome abundant; bundles all strongly girdered to lower side, some feebly to upper. Stereome-bands also above bundles.

Melrose. June 1901.

Exactly as above.

ii. No girders: stereome subepidermal only.

* Stereome in a continuous layer.

FESTUCA OVINA (Pl. **36.** fig. 3). Swanton Morley, Norfolk. June 1901.

Leaf subulate; ribs few. Very few short hairs on upperside, none below. Vascular bundles few, inner sheath not marked. Stereome-bands below most bundles, none above.

Royal Botanic Garden, Edinburgh. May 1901.

Hairs rather more abundant above. Stereome rather more spread out under lower epidermis. Otherwise as above.

(Pl. 36. fig. 4.) N. Wales. July 1900.

Only three ribs and two groups of motor cells. Stereome forms an almost continuous layer under the lower epidermis, none on upperside.

** Stereome in separate hypodermal strands.

† Stereome-strands not larger than principal vascular bundles.

‡ Motor-cell groups small and restricted to a row on either side the midrib.

§ Upper channel deeper and wider than the leaf is thick. Hairs few or none.

AIRA PRÆCOX (Pl. 36. fig. 5). Burntisland, Fife. May 1901.

Midrib slightly marked and two other very low ribs. Leaf rather thick and folded. No hairs. Bundles of first and third orders; all have double sheath. Stereome forms small bands below bundles, none above.

AIRA CARYOPHYLLEA. Elsing, Norfolk. June 1902.

Midrib faintly marked, and one other rib on each side slightly marked above. Lower side angular. Lower epidermal cells with flat outer sides. Few sharp hairs above on ribs. Bundles seven, of second and third orders; both sheaths present, but inner is inconspicuous in smaller bundles. Stereome very scanty, small bands below bundles, none above.

§§ Channel narrower than the thickness of the leaf.

AIRA FLEXUOSA (Pl. 36. fig. 6). N. Wales. July 1900.

Leaf-section angular. Upperside reduced to a mere depression. Lower (outer) epidermal cells flat. Short hairs abundant on upperside. Five bundles, large central one of first order, others of second and third orders. All have prominent double sheath. Stereome forms almost a continuous band under lower epidermis and a band above midrib on upperside.

‡‡ Motor cells in all the (about 4) grooves.

FESTUCA OVINA. (See p. 327, above.) (Pl. 36. fig. 3.)

FESTUCA RUBRA (Pl. 36. fig. 7).

Upper leaf. Upperside with few ribs, midrib strongly marked. Hairs rather few and short above. Bands of stereome above and below most bundles, those below bundles stronger than those above.

†† Stereome-strands stronger than principal vascular bundles, and tending to fuse laterally. Rings of chlorophyll-tissue round the bundles.

LEPTURUS FILIFORMIS (Pl. 36. fig. 8). Newquay, Cornwall. July 1902.

Leaf subulate. Upperside with few ridges and grooves. Hairs fairly numerous above, short and sharp; none below. Cells of lower epidermis flat, of upper rather papillose. Cells of lower epidermis between the stereome-groups much larger than others. Bundles with both sheaths conspicuous. Stereome abundant, on outer side only; very strong band below central bundle and smaller ones under smaller bundles, the latter sometimes fusing. Chlorophyll-tissue continuous and in rings around bundles.

B. Section crescentic or curved in, obvious owing to inrolling of the lamina. Stomata above only or (in *Festuca Myuros*) a few also below. Epidermal cells strongly cutinized, especially below.

a. Stereome abundant and fusing below into thick hypodermal bands and half-girders. Section involute.

ELYMUS ARENARIUS (Pl. 36. fig. 9), in upper part of leaf (see p. 330).

b. Stereome in isolated strands; no girders. Sections crescentic.

i. Hairs obsolete or nearly so.

AGROSTIS VULGARIS, var. PUMILA (Pl. 36. fig. 10). Arran. June 1901.

Ribs of two orders, midrib one of smaller. Lower epidermal cells flat. Vascular bundles of three orders, the larger ones in the smaller ribs. Bundles of first order girdered below, in midrib also above. Others have bands of stereome above and below. Stereome in some cases below motor cells on lower side of leaf. (See p. 335.)

ii. Hairs long and numerous above.

* Hairs strong and longer than the leaf-thickness.

FESTUCA MYUROS. Elsing, Norfolk. June 1901.

Leaf at ribs about double the thickness it is at grooves. Motor cells nearer the midrib more conspicuous. Bundles of two orders; the larger have a fairly strong inner sheath. Stereome in feeble bands below most bundles. (See also p. 331, below.)

** Hairs shorter than the leaf-thickness.

KOELERIA CRISTATA (curved leaves). (See p. 331.)

FESTUCA ELATIOR, var. ARUNDINACEA (Pl. 36. fig. 11). Hunstanton, Norfolk. July 1900.

Upperside with few but well-marked ribs. Leaf rather thick. Lower epidermal cells flatter. Bundles with both sheaths well marked. Stereome forms bands above and below bundles; those below bundles are very broad and form an almost continuous sub-epidermal layer.

II. Leaf-sections linear and many times broader than deep—*i. e.*, lamina more or less flattened out. Vascular bundles, stomata, and motor cells usually numerous, and lower epidermis usually more strongly cutinized than upper.

A. Ridges more or less conspicuous above; the principal at least as high again as the thickness of leaf-tissue in the grooves between.

a. Hairs present.

i. Hairs conspicuous in number or length or both.

* Stereome strongly developed; stomata above only. Epidermal cells very strongly cutinized, especially below.

† Stereome as a thick continuous layer below, with strong girders and half-girders to the vascular bundles.

‡ Horizontal girders in large ribs.

PSAMMA ARENARIA (Pl. 36. fig. 12). N. Wales. July 1900.

Ribs conspicuous and unequal, from 3 times to 1¼ times the thickness of the leaf between. Tops of ribs rounded. Stomata confined to flanks of ridges. Numerous hairs on upperside only. Bundles of three orders, corresponding to ribs. All have very strong inner sheath and an outer sheath. Stereome very abundant; it forms a strong subepidermal layer on underside; girders above and below to most bundles, also side-girders to some of the larger bundles. Chlorophyll-tissue restricted in amount.

[The most "typical" of British maritime grasses in its leaf-structure (compare with *Agropyrum junceum* and with *Elymus arenarius*). The lateral girders of stereome to the bundles are peculiar to this leaf.]

‡‡ No horizontal girders.

AGROPYRUM JUNCEUM (Pl. 36. fig. 13). N. Wales. July 1900.

Ridges two to three times as high as leaf-thickness between, more uniform than in *Psamma*. Larger ribs with square, others with rounded tops. Cells of lower epidermis flat. Numerous rather short hairs above only. Bundles large, of three orders, corresponding to ribs; all have very well-marked inner and outer sheaths. Stereome abundant as a subepidermal layer on underside, and half-girders to larger bundles below; also bands above bundles connected in large ribs to bundle-sheath by bands of colourless cells.

[Although *A. junceum* is sometimes regarded as merely a variety of *A. repens*, the difference in leaf-structure between the two is very considerable; moreover, the differences can all be regarded as adaptations to the environment. The high ribs covered with hairs, the strong cuticle of the lower epidermis, and the absence of stomata from the lower side of the leaf of *A. junceum* all tend, with the frequent rolling up of the leaf, to the reduction of transpiration. The greater amount of stereome in this leaf is due probably to the more exposed conditions in which *A. junceum* is found, and the greater storms &c. to which it is subjected; the development of the subepidermal stereome-band is probably an adaptation to secure mechanical support when the leaf is unrolled.]

†† Girders, but no continuous layer of stereome.

ELYMUS ARENARIUS (Pl. 36. fig. 14). Hunstanton, Norfolk. July 1900.

Upperside with well-marked ribs of two orders, of which the largest are twice the height of the leaf-thickness between. Large ribs with square, others with rounded tops. Lower side flat. Numerous short stout hairs above; none below. Bundles large, of three orders, one to each rib corresponding in order to ribs. Both sheaths conspicuous in all bundles. Stereome abundant; all bundles girdered below and the larger ones above also; stereome-bands above smaller bundles.

At the tip (fig. 9) the ribs are low and the stereome is very abundant. (See above, p. 329.)

** Stereome inconspicuous or in isolated strands, but not forming girders. Epidermal cells strongly cutinized below, less so above.

† Motor-cell groups conspicuous. Very hairy both sides. Stomata above only.

KOELERIA CRISTATA (Pl. 36. fig. 15). Royal Botanic Garden, Edinburgh. June 1901.

Thickness of leaf at ridges about double that at grooves. Larger ribs square, others rounded; a few very low. Bundles of three orders, larger ones in ribs, and one or two of the smallest between these. Largest bundles have strong inner sheaths. Stereome takes the form of thin plates (one cell thick) within the epidermis.

Gullane, Haddington. June 1901.

Exactly as above, but smaller and less hairy.

[The leaf-structure shows a higher degree of xerophily than is usual in pasture-grasses, and the grass is capable of growing under somewhat xerophilous conditions.]

†† Motor cells inconspicuous.

‡ Hairs and numerous stomata on both sides.

HORDEUM MARITIMUM (Pl. 36. fig. 16). Hunstanton, Norfolk. August 1901.

Low, rounded ribs above. Bundles few, of two orders; central bundle alone with marked inner sheath. Stereome forms feeble bands above and below some of the bundles.

‡‡ Hairs on upperside only.

§ Hairs short, stiff, and rather sparse.

FESTUCA RUBRA. Bridge of Allan. May 1901.

Lower leaf. Midrib obsolete. Rather sparse and short hairs above, none below. Lower epidermal cells flat, upper arched. Bundles of two orders, larger ones with well-marked inner sheath. Bands of stereome above and below bundles. (See also p. 328.)

FESTUCA MYUROS, var. BROMOIDES. Edinburgh. May 1901.

Ribs few on upperside. Hairs on upperside of ridges rather short, but strong. Stereome feeble, bands below stronger bundles and some above.

[In contradistinction to the species of *Poa* those of the genus *Festuca* possess leaves which show a considerable amount of structural differentiation. The two wet meadow species, *F. elatior* and *pratensis*, possess a leaf-structure which is fairly characteristic of meadow-grasses. Comparing with these the leaf-structure of *F. Myuros* and its variety *bromoides* from sandy places, we notice that no very great structural modification has taken place. The leaves are much smaller, and dependent upon this the stereome is considerably less abundant. Hairs are developed upon the upper surface, and there is a greater difference between the lower and the upper epidermis in the cutinization and in the number of stomata; these differences all point to a greater degree of xerophily. The small amount of stereome present on the upperside of the leaf indicates a slight approach to the heath-grass type of leaf-structure.

F. arundinacea, a variety of *F. elatior,* again shows an approach to the maritime type of xerophilous leaf-structure. The ribs have become more prominent and are covered with numerous hairs; the cells of the lower epidermis are strongly cutinized and have a flat outer surface, while the stomata are confined to the flanks of the ridges: all these differences show a high degree of xerophilous modification. The arrangement of the stereome, chiefly in broad bands under the lower epidermis, depends upon the narrowness of the leaf and the fact that this is generally folded.

The remaining species show very clearly a gradual change from the meadow-grass to the heath-grass type of leaf-structure. In *Festuca duriuscula,* which is characteristic of drier pastures than *F. elatior* and *F. pratensis,* we find a smaller number of ribs, which are covered with hairs ; of these the midrib is the largest, though not conspicuously so ; we find also the lower epidermal cells strongly cutinized and with flat outer surfaces, and that the stomata are confined to the upperside of the leaf ; these changes are all in the direction of greater xerophily ; again, we find that the stereome, which is much smaller in amount owing probably to the smaller size of the leaf, is practically confined to the lower side. The lower flat leaves of *F. rubra* are very similar in structure to those of *F. duriuscula,* the chief difference being the shorter hairs and the presence of a fair amount of stereome on the upperside. The upper subulate leaves, however, show a distinct advance ; the midrib is relatively much more prominent, and there are only four other ribs. In some specimens of *F. ovina* (Pl. **36**. fig. 3) we get a very similar leaf-structure to that just mentioned, only the midrib is relatively even more prominent and there is no stereome on the upperside. In other specimens of the same species (fig. 4) the type is even higher ; there are only two ribs besides the midrib, and the stereome forms an almost continuous subepidermal band. We have thus arrived by easy stages at what is a quite typical leaf-structure for a heath-grass.]

§§ Hairs long and numerous.
|| Stomata on upperside only.

FESTUCA DURIUSCULA (Pl. **37**. fig. 17). Kinghorn, Fife. May 1901.

Rather few but well-marked ribs on upperside. Abundant, fairly long, strong hairs on upperside. Vascular bundles few, of two orders. Stereome in small bands, mostly on lower side. Larger bundles have strong inner sheaths.

|||| A few stomata below also, as a rule.

FESTUCA MYUROS. (See p. 331, above.)

ii. Hairs inconspicuous or none. Cutinization of epidermal cells usually moderate or feeble, that of the lower surface the stronger.
* Asperities or sparse short hairs, chiefly above.
† Stereome forming girders to some or all vascular bundles.
‡ Motor-cell groups conspicuous in all the grooves.
§ Stomata fairly numerous on both surfaces.

ALOPECURUS PRATENSIS (Pl. **37**. fig. 18). Swanton Morley, Norfolk. June 1901.

Ribs of two orders, both rounded. Stereome fairly abundant, many bundles girdered to lower side and with bands above; bands also above and below, or only below other bundles.

Kinghorn, Fife. May 1901.
Exactly as above.

Royal Botanic Garden, Edinburgh. May 1901.
Same, but some of central grooves have disappeared.

§§ Stomata more numerous above.

Festuca pratensis. Cherry Hinton, Cambs. August 1900.

Ribs higher than in *F. elatior*, of various orders. Grooves on either side of midrib shallow. Lower epidermal cells flatter than upper. Bundles of three orders, corresponding to ribs; all have both sheaths fairly conspicuous. Stereome abundant; girders most of bundles to lower side and forms bands above, which are joined to bundle-sheath by bands of colourless cells.

‡‡ Motor cells inconspicuous.

§ Stomata numerous on both surfaces.

Bromus mollis. Kinghorn, Fife. May 1901.

Bundles of three orders, all with both sheaths well marked. Stereome forms girders to largest bundles, and bands above and below some of others.

§§ Stomata numerous above, few below.

Agrostis canina (Pl. 37. fig. 19). Ben Ledi. June 1901.

Both upper and lower epidermal cells fairly strongly cutinized. Stereome forms girders to largest bundles above and below, other bundles with bands of stereome above and below; bands also just inside lower epidermis opposite grooves.

†† Stereome relatively feeble, and not forming true girders to vascular bundles.

‡ Motor-cell groups conspicuous.

§ Ridges 5–6 times as high as leaf-tissue between, triangular, and each with 1–3 vascular bundles and short asperities. Stomata chiefly on flanks of ridges.

Aira cæspitosa (Pl. 37. fig. 20). Cambridge. July 1900.

Cells of both upper and lower epidermis well cutinized and flat. Two or three vascular bundles in each rib, one of first order, others of second and third. All have well-marked double sheath. Stereome strong, in bands at tips of ribs, below largest bundles and some of smaller ones, under lower epidermis opposite the motor cells. Below motor cells are bands of thin-walled, colourless cells, which join these to stereome.

[*Aira cæspitosa* is so very different in leaf-structure from the other species of the genus that it is practically useless for purposes of comparison. Moreover, its leaf-structure, as will be seen below, is not that characteristic of either meadows or wet places, although its resemblance to *Alopecurus geniculatus* (Pl. 37. fig. 21), also occurring in wet places, ought to be mentioned; however, the characters of the epidermis are very different in the two leaves. *A. caryophyllea* and *A. præcox*, both found in dry exposed situations, have the leaf-structure practically identical. The leaves of both these grasses are very small, and the structure might be described as a reduced "heath" type. Comparing the structure of these leaves with that of the leaf of *A. flexuosa*, a typical heath-grass with long awl-shaped leaves, we see that all the distinguishing characters of the latter are in the direction of greater xerophilism. The upper surface of the leaf is more reduced and is covered with hairs; the lower epidermal cells are more strongly cutinized, and the stereome on the lower side of the leaf is more abundant; this last character, however, is probably directly dependent upon the larger size of the leaf. It is thus not difficult to imagine how the leaf-structure of *A. caryophyllea* and *A. præcox* and that of *A. flexuosa* may have been derived from a common type, the two former by a reduction consequent on the reduction of the leaf itself, the latter by increased specialization to meet the xerophilous conditions under which it grows.]

§§ Ridges not more than 2–3 times as high as tissues between, and only one vascular bundle in each.

|| Short stiff hairs on crests of ridges both sides. Stomata about equally abundant both sides.

AGROSTIS SPICA-VENTI (Pl. 37. fig. 22). Royal Botanic Garden, Edinburgh. July 1901.

Ribs shown on both sides; midrib the least prominent, others uniform. Epidermal cells arched on both sides. Stereome forms bands above and below bundles. Hairs fairly frequent on both sides at summits of ridges.

[*Agrostis* is a genus of grasses in which the leaf-structure is very uniform. It is true that most of the species are characteristic of either pastures or wet places, between which groups, as we shall see later, there is very little difference in leaf-structure. But even *A. canina,* which is a heath-grass, is very little different from *A. vulgaris,* and does not show the least approach to the "typical" leaf-section of heath-grasses. *A. Spica-venti* has the most distinctive leaf-section, but even here the modifications do not show any relation to the environment.]

|||| No hairs or asperities below, but a few on crests of ridges.

¶ Chlorophyll-tissue in rings or partial rings around the vascular bundles.

POA RIGIDA (Pl. 37. fig. 23). Saxlingham, Norfolk. August 1900,

Rounded ribs; lower side flat. Stomata more abundant above. A few short stiff hairs above, none below. Bundles have double sheath, but inner is not well marked, except round central bundle. Stereome in small bands above and below some of bundles, above others. Chlorophyll-tissue in rings around bundles.

POA LOLIACEA. Newquay, Cornwall. July 1902.

Upperside with well-marked, rounded ribs (higher than in *P. rigida*). Lower side flat. Cells of both upper and lower epidermis strongly cutinized (those of lower rather the stronger) and flat. Stomata on the flanks of the ridges. Bundles of two orders, all with well-marked double sheath. Stereome-bundle in midrib feebly girdered below, others have bands above only. Chlorophyll-tissue more or less in rings about bundles (not so strongly marked as in *P. rigida*).

[As regards leaf-structure we must divide the species of *Poa* into two groups: the first includes *Poa annua, pratensis, compressa, trivialis, nemoralis, bulbosa,* and *alpina*; the second includes *Poa rigida* and *loliacea.* The last two species, moreover, are often removed from this genus and placed either in *Festuca* or *Sclerochloa,* and their leaf-structure certainly resembles that of some species of *Festuca.* Taking only the first group into consideration, we have an excellent example of how the leaf-structure may remain constant through several allied species, in spite of great differences in the environment. We have representatives here of meadow, waste-place, alpine, maritime, and wood grasses, and yet it is practically impossible to recognize any one from its leaf-structure, the only species that it might be possible to recognize being *Poa bulbosa* and *P. alpina.* The former differs chiefly in the smaller size of the leaf, the latter in the greater thickness of the leaf and the stronger cutinization of the epidermal cells. *P. alpina,* then, may be said to have its leaf-structure modified to fit it for its environment; but this is the only case in the group, and even here the modification is very slight. The differences between the leaf-sections of the other species are of minor importance and are all liable to variation.

Poa rigida and *P. loliacea* are both xerophilous in habitat, and the leaf-structure is very similar, especially in the arrangement of the chlorophyll-tissue, the small amount of stereome present, &c. *Poa loliacea* is rather more strongly xerophilous in its leaf-structure than *P. rigida*, and in both the distribution of the motor cells is significant.]

¶¶ Chlorophyll-tissue normal in type. Stomata more numerous above.

LOLIUM TEMULENTUM (Pl. 37. fig. 24). Royal Botanic Garden, Edinburgh. July 1901.

Dome-shaped ribs on upperside; midrib not specially marked. Larger bundles half-girdered below and with bands of stereome above, others with bands above and below; smaller ones with bands above only. Outer sheath to bundles well marked, inner less so. Chlorophyll-tissue interrupted at most of the larger bundles.

With a similar habitat, the leaf-structure of the two species of *Lolium* is also very much the same. In both cases it is fairly typical for meadow-grasses.

ALOPECURUS ALPINUS (Pl. 37. fig. 25). Royal Botanic Garden, Edinburgh. April 1901.

Stomata very abundant, especially on upperside. Vascular bundles few. Stereome in bands at summits of ridges, below bundles, and below groups of motor cells. Chlorophyll-tissue very loose.

‡‡ Motor cells not conspicuous.

§ No hairs or asperities. Stomata more numerous above.

AGROSTIS VULGARIS, var. PUMILA (Pl. 36. fig. 10). (See p. 329, above.)

§§ A few short hairs or asperities.

|| Rather sparse, short, stiff hairs both sides.

ALOPECURUS AGRESTIS. Fulbourn, Cambs. July 1900.

Upperside with ribs rounded and uniform. Ribs slightly marked below. Stomata about equal on the two sides. Vascular bundles with double sheath, though the outer is not always clear. Only one or two bundles girdered, others with bands of stereome above and below, or above or below only. Bands also under lower epidermis between the ribs.

|||| Asperities on upper surface only.

LOLIUM PERENNE. Burntisland, Fife. May 1901.

Well-marked ribs on upperside, flat below. Stomata more abundant above. None of the bundles girdered; bands of stereome above and below all the bundles.

Quy, Cambs. August 1901. (Inflorescence branched.)

Differs only in that a few of the ribs are slightly marked below.

ALOPECURUS GENICULATUS (Pl. 37. fig. 21). Melrose. June 1901.

Lower side smooth. Epidermal cells somewhat papillose, especially above. Stomata very abundant on both sides. Vascular bundles of two orders; those of first order have both sheaths well marked, but in those of second order the inner sheath is not conspicuous. Small bands of stereome above and below all bundles, and on lower side between them, opposite the motor cells.

[We have in the genus *Alopecurus* representatives of four natural groups of grasses—meadow, wayside, alpine, and water. The leaf-structure in each shows a strong family resemblance to the others, the most striking difference being the higher ribs of *A. alpinus* and *A. geniculatus*; in neither case are high ribs characteristic of the habitat. Comparing the others with *A. pratensis* (meadow) we see that *A. agrestis* (wayside) shows practically no difference, except that it possesses rather less stereome; *A. alpinus* differs in the height of the ridges and also in the much smaller amount of stereome present, the latter feature may be regarded as an adaptation to its environment. *A. geniculatus*, again, differs in the higher ribs and much smaller amount of stereome, but also in the greater abundance of stomata on both sides, and in the loose arrangement of the chlorophyll-tissue; the last three features certainly can be looked upon as adaptations to moister conditions of life. Probably the resemblance between *A. alpinus* and *A. geniculatus* is connected with the similarity of habitat, though the former is found only in alpine wet places, while the latter is a lowland form.]

B. Ridges inconspicuous or obsolete.
  a. Midrib evident or prominent as a keel below.
    i. Hairs conspicuous in number or length or both. Stomata on both surfaces, but more numerous above.
      * Stereome relatively prominent as girders to all or most vascular bundles.
        † Motor cells between all the ribs, except the midrib and those flanking it. Epidermal cells of lower surface strongly cutinized, upper less so.

BROMUS ASPER (Pl. 37. fig. 26). Edinburgh. July 1901.

Midrib projects below, otherwise leaf-surfaces practically parallel. Strong hairs; some short, others long, generally above or below a bundle. Three bundles in midrib. Bundles of three orders, sheaths not always conspicuous. Stereome forms girders to all the larger bundles, at least below.

Cambs. Aug. 1900.

Similar to above.

[See also *B. sterilis*, p. 337.]

†† Motor cells between all the ribs. Hairy above, and stomata much more numerous there.
  ‡ Motor cells conspicuous.

BRACHYPODIUM SYLVATICUM. Cambs. June 1900.

Leaf very thin in comparison with breadth. Lower epidermal cells very strongly cutinized and with flat outer surfaces. Upper cells much less so and arched. Fairly abundant, short, sharp hairs and a few long stout hairs, mostly on upperside. Bundle-sheaths not well seen in smaller, but fairly conspicuous in larger ones. Stereome girders most bundles below and bands above bundles.

‡‡ Motor cells inconspicuous.

MELICA NUTANS. Linlithgow. June 1901.

Leaf very thin and broad. Hairs abundant above. Cells of neither epidermis strongly cutinized, those of lower rather more so than upper; all the cells are somewhat arched. Stereome forms girders to all bundles above and below.

** Stereome restricted to isolated bands and not forming girders. Very hairy on both sides.

Bromus sterilis (Pl. 37. fig. 27). Linlithgow. June 1901.

Cells of neither epidermis strongly cutinized. Motor cells sometimes none at sides of central bundle. Stereome forms half-girders below most of the bundles of first and second order, also above most of those of first order; smallest bundles have no bands above or below.

ii. Hairs few, inconspicuous, or none. Stomata on both surfaces, but usually more numerous above.

* Short sharp hairs or asperities, usually on upper surface only.

† Stereome relatively abundant as girders to some or all vascular bundles.

‡ Motor cells restricted to two series flanking the midrib, and conspicuous. Epidermal cells fairly strongly cutinized, especially below.

Avena pratensis (Pl. 37. fig. 28). Ben Lawers. July 1901.

Midrib projects below and slightly above, grooves on either side above; otherwise leaf-surfaces parallel and flat. Leaf thick in comparison with breadth. Lower epidermal cells flat; upper arched. Stomata rather more frequent above. Bundles all have both sheaths well marked. Stereome forms girders below bundles nearest midrib, and bands above and below or only above other bundles.

Harston, Cambs. May 1902.

Leaf very much as above, but rather larger. There are more bundles, some of which have no stereome above or below. Bundle in midrib and in some others have girders below.

Avena pratensis, var. alpina. Royal Botanic Garden, Edinburgh. May 1901.

Leaf very broad and thick. Midrib sunk above. Stereome forms girders to some of the bundles, bands above and below others.

[Except that *A. alpina* possesses a much larger leaf, there is practically no difference in leaf-structure between it and the true *A. pratensis*. The change of environment, such as it is, has had no effect on the structure of the leaf.]

Poa compressa. Kinghorn, Fife. May 1901.

Lower epidermal cells flat, upper arched. A few short stiff hairs above, mostly over bundles. Bundles very numerous and close, of three orders. All have conspicuous double sheath. Stereome forms girders below and bands above larger bundles (but only bands in the midrib) and bands above or below or none to smaller bundles.

Poa nemoralis. Bridge of Allan. May 1901.

A few short hairs above over the bundles. Bundles in midrib not girdered below, other large bundles girdered above and below; stereome-bands above and below or only above smaller bundles or none.

‡‡ Motor cells in all intervals between ribs and conspicuous.

§ Large air-cavities in leaf-tissue on each side of the midrib.

Molinia cærulea (Pl. 38. fig. 29). N. Wales. July 1900.

Leaf rather thin. Ribs square. Epidermal cells small and strongly cutinized on both surfaces. Motor cells very conspicuous. Bundles of three orders, the larger ones contain a large number of fibres and have an exceedingly strong inner sheath; these points are less marked towards the margin of the leaf. Stereome very strong; it forms girders to most of bundles, also a subepidermal band in midrib. Chlorophyll-cells polygonal, small and closely packed.

[Not a typical heath-grass nor a typical aquatic grass, but the leaf-structure shows features which are characteristic of both groups.]

§§ No conspicuous air-cavities in mesophyll.

HIEROCHLOË BOREALIS (Pl. 38. fig. 30). Royal Botanic Garden, Edinburgh. May 1901.

Lower epidermal cells flat and well cutinized, those of upper epidermis less so. Motor cells very conspicuous. Bundles mostly large. Stereome strong, forming girders to large bundles and bands below smaller ones.

AGROPYRUM REPENS. Cambridge. July 1900.

Lower epidermal cells rather more strongly cutinized than upper, neither very strong nor flat. Bundles numerous, of three orders. Three bundles in midrib, one in each of other ribs. All have both sheaths, though not always, marked. Stereome abundant; girders to the larger bundles; other bundles may be girdered or have bands above and below or none.

HORDEUM MURINUM. Cambridge. July 1900.

Neither epidermis strongly cutinized. Short sharp hairs, more numerous above. Bundles three in midrib, one in each of the other ribs. Larger bundles girdered, at least below; no stereome in connection with smaller bundles. All bundles have both sheaths, though they are not conspicuous.

[As regards the genus *Hordeum*, we should not perhaps expect to find any marked difference in leaf-structure between *H. pratense* and *H. murinum*, one being found in meadows, the other in waste places; and there certainly are no differences that can be regarded as due to the influence of the environment. The chief difference between the two leaves is the prominent midrib of *H. murinum*, that of *H. pratense* not projecting below and not being in any way marked off from the other ribs. *H. pratense* is more hairy than *H. murinum*, but this is a character liable to variation; also the former possesses more abundant stereome. Moreover, when we consider the stunted habit of *H. maritimum*, especially the small size of the leaves, and its short period of vegetation, we should not expect it to possess markedly different leaf-structure, in spite of its more xerophilous habitat. This we find to be the case, its leaf-structure being feeb er than that of the other two species, and in no way showing any modification in the direction of greater xerophily, but rather the reverse.]

BROMUS GIGANTEUS. Cambridge. July 1900.

Cells of lower epidermis slightly more strongly cutinized and flatter than those of upper. Somewhat sparse, short, stiff hairs above only. Bundles of three orders; all have both sheaths, but the cells of inner one are not very thick-walled. Larger bundles girdered at least to lower side, others have bands of stereome above and below, or below or above, or none.

[This grass is sometimes included in the genus *Festuca*; the leaf-structure differs from that of any species of *Festuca*, but resembles closely that of the other species of *Bromus*.

Though we have in the genus *Bromus* representatives of three œcological groups, the differences in leaf-structure are very small, so much so that one cannot with certainty identify any one species. The abundant hairs of *B. sterilis* may be regarded as an adaptation to its environment, and similarly with the thinness of the leaf of *B. asper*. The other differences met with in the leaves are liable to variation and cannot be considered environmental adaptations.]

†† Stereome relatively scanty, and at any rate not forming true girders to the vascular bundles.

‡ Motor cells conspicuous in a single series over the midrib.

DACTYLIS GLOMERATA (Pl. 38. fig. 31). Swanton Morley, Norfolk. June 1901.

Midrib rather depressed above; a few blunt asperities. Epidermal cells not strongly cutinized. Stomata above and below in about equal numbers. Central bundle not girdered, but with a strong band of stereome below; other large bundles girdered above and below, smaller ones have bands of stereome variously arranged. At base of blade occur large intercellular spaces appearing between most pairs of bundles, and the stereome more abundant.

Burntisland, Fife. May 1901.

As above, except that stereome is slightly less abundant.

‡‡ Motor cells in two or more series.

§ Motor cells restricted to the flanks of the midrib.

|| Motor-cell groups conspicuous.

POA NEMORALIS, var. BALFOURII. Ben Lawers. July 1901.

Stomata on both sides. Stereome not abundant, it forms bands above and below all bundles.

|||| Motor-cell groups inconspicuous.

POA TRIVIALIS. Swanton Morley, Norfolk. June 1901.

Midrib strongly and other main ribs slightly marked below only. Upperside has short sharp hairs. Bundles of three orders; the largest have both sheaths well marked, in smaller the inner one is less conspicuous. Bands of stereome above and below bundles.

Edinburgh. May 1901.

No ribs marked below, except midrib. Most bundles are half-girdered at least below.

POA PRATENSIS. Ben Ledi. July 1901.

A very few hairs. Nearly all vascular bundles have the inner sheath well marked. Stereome forms girders above and below or only below some bundles, bands above and below others.

§§ Motor cells in inconspicuous shallow groups between all the ribs. Sparse hairs above and below.

MELICA UNIFLORA (Pl. 38. fig. 32). Royal Botanic Garden, Edinburgh. April 1901.

Leaf very thin, with a few ribs below, corresponding to each of larger bundles. Hairs few, confined to lines above and below bundles. Vascular bundles few. Stereome not well developed, forming bands above and below nearly all bundles.

Roslin. May 1901.

Exactly as above.

[Both species of *Melica* are typical wood-grasses, and there are no important differences in leaf-structure between them. In both cases the leaf-structure seems well adapted for conditions not favourable to great transpiration. The minor differences between the leaves cannot, except perhaps the hairs of *M. nutans*, be recognized as adaptive.]

** No hairs or asperities; surfaces smooth or at most slightly papillose.

† Stereome relatively prominent, forming girders to some or all bundles.

‡ Motor cells confined to two conspicuous series flanking the midrib. Traces of papillæ above.

POA ALPINA (Pl. 38. fig. 33). Ben Lawers. July 1901.

Leaf-surface parallel. Lower epidermal cells very strongly cutinized, upper much less so and somewhat papillose. Few or no stomata below. Larger bundles (not that in midrib) girdered below and with bands of stereome above; other bundles with bands above, or above and below, or none. In larger bundles both sheaths are well marked, in smaller the inner sheath is inconspicuous. Chlorophyll-tissue interrupted at larger bundles.

‡‡ Motor cells not restricted to flanks of midrib.

§ Large groups of motor cells flanking the midrib, and smaller but conspicuous groups between the other ribs. No hairs.

TRIODIA DECUMBENS (Pl. 38. fig. 34). Arran. June 1901.

Leaf thick and quite flat above and below, except for midrib, which is sunk above. Lower epidermal cells extremely strongly cutinized, upper less so. Bundles fairly large, all with well-marked double sheath. Stereome-cells very strong. Most of the bundles girdered. Chlorophyll-tissue of small cells closely packed.

[A heath-grass with a leaf that differs considerably from that typical of the group, but still fairly well adapted to its conditions.]

§§ Motor cells between all the ribs alike.

|| Motor-cell groups very conspicuous. Stomata on both surfaces.

MILIUM EFFUSUM (Pl. 38. fig. 35). Royal Botanic Garden, Edinburgh. May 1901.

Leaf broad. Cells of neither epidermis strongly cutinized, or with flat outer surfaces. Bundles far apart, of three orders. Larger bundles have both sheaths marked; in smaller ones inner sheath not well shown. Bundles of first order girdered above and below, others with only a band of stereome above.

|||| Motor cells not conspicuous. Stomata more abundant above.

ARRHENATHERUM AVENACEUM. Ilford, Essex. August 1901.

No hairs. Neither epidermis has its cells very strongly cutinized. Midrib with one large and two small bundles, other bundles of three orders. Largest bundles strongly girdered to both sides, smaller ones only girdered below.

Edinburgh. July 1901.

Structure the same, except that some of smaller bundles are not girdered.

BROMUS ERECTUS. Fulbourn, Cambs. May 1902.

Midrib marked above and below. Cells of neither epidermis very strongly cutinized, those of lower rather the stronger and outer margins flatter. Bundles numerous, of three orders. In smaller bundles both sheaths are well seen; in larger, inner sheath is conspicuous, but outer is less so. Largest bundles girdered strongly above and below; smaller bundles have generally no bands, occasionally girdered above.

†† Stereome relatively scanty, or at any rate not forming true girders.

‡ Motor cells absent. Chlorophyll-tissue in rings round the vascular bundles. No hairs.

SETARIA VIRIDIS (Pl. 38. fig. 36). Cambridge. October 1901.

Epidermal cells, excepting guard-cells of stomata, very large, each occupying nearly one-third of the depth of the cross-section. Vascular bundles very numerous and most of them very small. Outer sheath of bundles very well marked. The midrib with girder to bundle below; other large bundles have bands of stereome above and below, and occasionally one of the small bundles has a band above. Large mass of colourless parenchyma in midrib above bundle.

A colonist, merely introduced in Britain. Leaf-structure very peculiar among British grasses.

‡‡ Motor cells restricted to two series flanking the midrib. Chlorophyll-tissue normal.

§ Motor-cell groups conspicuous.

|| Large air-chambers in tissue. No hairs.

GLYCERIA AQUATICA (Pl. 38. fig. 37). Cambs. July 1900.

Midrib with a groove on either side; otherwise leaf-surfaces flat and parallel. Leaf thick and broad. Epidermal cells on both sides fairly well cutinized. Bundles large, of three orders; all have well-marked outer sheath, but inner is less conspicuous. Stereome-bands above and below bundles, also numerous small subepidermal bands on both sides between the larger ones. Large air-lacunæ between the bundles reduce the chlorophyll-tissue to a few layers surrounding them.

|||| No conspicuous air-cavities. Epidermis feebly cutinized.

¶ Traces of papillæ. Stomata numerous on both sides.

CATABROSA AQUATICA (Pl. 38. fig. 38). Swanton Morley, Norfolk. June 1901.

Upperside with a few low, rounded elevations not corresponding to the vascular bundles. Midrib projects above and below. Some of the epidermal cells are papillose. Vascular bundles numerous. Stereome in fairly strong bands above and below larger bundles, and smaller bands above or below some of smaller ones. Chlorophyll-tissue rather spongy; it is interrupted at larger bundles by bands of thin-walled colourless cells, which join the bundles to the stereome-bands.

Arran. June 1901.

Exactly as above.

¶¶ Surfaces quite smooth.

POA ALPINA, var. VIVIPARA. Ben Lawers. July 1901.

Agrees with description of *P. alpina* (see p. 340), except that there is rather less stereome and no bundles are girdered.

POA ANNUA. Cambridge. July 1900.

Leaf rather thin. Cells of epidermis arched. Stomata few on both sides. Sheaths not well marked. Stereome-bands above and below or only below to bundles.

§§ Motor-cell groups inconspicuous. Surfaces slightly papillose. Air-chambers in tissue. Stomata about equal both sides.

GLYCERIA FLUITANS (Pl. 38. fig. 39). Swanton Morley, Norfolk. June 1901.

Epidermal cells on both sides mostly raised into papillæ. Vascular bundles large and numerous, between the ridges. Stereome feeble, bands above and below bundles. Fairly large air-lacunæ between bundles. Bands of thin-walled colourless cells join bundles to stereome.

Linlithgow. June 1901.

Ridges less marked. Motor cells more conspicuous. Otherwise as above.

[With the same habitat, it is to be expected that the two species of *Glyceria* should have a similar leaf-structure, and it will be seen that these two grasses have one of the most characteristic leaf-structures among British aquatic grasses. The larger air-lacunæ of *G. aquatica* are probably dependent upon the larger size of the plant, and the stronger cutinization of the epidermal cells is probably due to the same cause, as the leaves are thereby more exposed to the wind. The low ribs of *G. fluitans* are harder to explain, they probably have no significance as an adaptive character.]

b. Midrib obsolete, or at least not prominent as a keel below. Stomata on both sides.

i. Hairs conspicuous in number or length, or both.

* Stereome relatively abundant, and forming girders to some or all vascular bundles. Motor cells between all ribs. Cutinization usually moderate.

† Motor-cell groups conspicuous. Stomata more numerous above.

‡ Hairs very numerous, rather short and sharp, on upper surface only.

HORDEUM PRATENSE (Pl. 38. fig. 40). Madingley Road, Cambs. August 1900.

Cells of lower epidermis fairly strongly cutinized and flat, those of upper less so. Stomata much more abundant above. Bundles all have both sheaths, but in those of third order the inner sheath is not conspicuous. Bundles nearly all girdered, some only to lower side, and with bands of stereome above.

‡‡ Hairs long, stiff, and fairly numerous both sides.

BROMUS MAXIMUS (Pl. 39. fig. 41). Royal Botanic Garden, Edinburgh. June 1901.

Cells of epidermis arched. Both sheaths fairly conspicuous. Stereome fairly abundant; some bundles are girdered on both sides, others have bands on both or on one side only, others have no bands above or below.

†† Motor cells inconspicuous. Stomata numerous on both surfaces.

‡ Hairs long and abundant on both surfaces.

HOLCUS MOLLIS (Pl. 39. fig. 42). Edinburgh. June 1901.

Leaf broad. Midrib contains one large bundle and two smaller ones. Hairs abundant, but shorter than in *H. lanatus*. Stereome forms girders to most bundles, at least below; the bands above are joined to the bundles by bands of colourless cells. The ribs become slightly more prominent near base of leaf. A small leaf higher up the culm of the same plant shows the same structure.

HOLCUS LANATUS (Pl. 39. fig. 43). Swanton Morley, Norfolk. June 1901.

Low, rounded ribs of three orders; those of the first order are rather square. The larger bundles have girders of stereome above and below, others have no stereome above or below. Towards base of leaf, midrib was marked on lower side and the grooves on either side of it were small, and there was more stereome.

Ilford, Essex. August 1901.

Agrees with above description of middle of blade, but the midrib is conspicuous below and the grooves above on either side of it are very small.

[As we should expect in two closely related grasses with the same habitat, there is no marked difference in the leaf-structure. Both show well the characteristic leaf-structure of grasses of waste places.]

‡‡ A few long hairs above.

BROMUS MOLLIS. (See p. 333, above.)

** Stereome inconspicuous, or at any rate not forming true complete girders. Hairs on both surfaces. Motor cells between all ribs.

† Motor-cell groups conspicuous. Stomata more numerous above.

LAGURUS OVATUS (Pl. 39. fig. 44). Royal Botanic Garden, Edinburgh. June 1901.

Flat below. Abundant longish hairs on both sides. Stereome feeble, a few of larger bundles girdered, smaller ones have no accompanying bands.

[The leaf-structure is that characteristic of the habitat, except for the rather feeble stereome.]

†† Motor cells inconspicuous. Stomata numerous on both sides.

HORDEUM MARITIMUM (Pl. 36. fig. 16). (See p. 331, above.)

ii. Hairs few, inconspicuous, or none.

* Short sharp hairs or asperities present.

† Stereome relatively abundant, and forming girders to some or all vascular bundles.

‡ Motor-cell groups conspicuous. Cutinization feeble.

§ Sparse, short, stiff hairs below. Stomata about equal on both surfaces.

DIGRAPHIS ARUNDINACEA (Pl. 39. fig. 45). Fulbourn, Cambs. July 1900.

Leaf-surfaces almost parallel. Ribs project very slightly both above and below. In the lower epidermis the cells in the grooves are larger than those covering the ribs; this gives to the leaf-section a curious double-faced appearance. Vascular bundles extremely numerous. All have fairly well-marked double sheaths. Stereome forms girders to larger bundles and bands above and below smaller ones.

§§ Asperities on both surfaces. Stomata more abundant above.

AGROSTIS STOLONIFERA. Cambridge. August 1900.

Leaf rather thin. Bundles numerous, of three orders. All have double sheath. Stereome forms bands above and below all bundles; some of larger bundles girdered. Stereome-bands also under lower epidermis opposite the grooves.

‡‡ Motor cells inconspicuous. Epidermis rather strongly cutinized.

§ Asperities on ribs below. Stomata on both sides.

PHLEUM PRATENSE (Pl. 39. fig. 46). Ilford, Essex. August 1901.

Short sharp asperities below bundles. Stereome forms girders below to nearly all bundles, girders above also to larger ones and bands above smaller bundles.

Swanton Morley, Norfolk. June 1901.

Practically as above, but there are no asperities. Also the vascular bundles are more numerous and some of the smallest are not girdered below.

§§ Asperities on both surfaces few. Stomata more numerous above.

AGROSTIS VULGARIS. Edinburgh. July 1901.

Ridges rounded. Lower side flat. All bundles have double sheath, though not always conspicuous. Stereome forms girders to larger bundles and bands above and below smaller bundles; also bands occasionally between the ribs, under the lower epidermis.

†† Stereome relatively inconspicuous, and rarely forming true or complete girders.

‡ Motor-cell groups restricted to two series flanking the midrib. Hairs few and short. Stomata far more numerous above.

POA BULBOSA (Pl. 39. fig. 47). Yarmouth, Norfolk. May 1902.

Leaf small, narrow, and rather thin. Lower epidermal cells not flat. Stomata much more abundant above than below. Sheaths not very well marked, especially in smaller bundles. Stereome in feeble bands above and below or above or below bundles.

‡‡ Motor cells between all the ribs. Stomata more numerous above.

§ Motor-cell groups conspicuous. Short, sharp, stiff hairs above.

‖ Chlorophyll-tissue tending to form rings round the bundles. Hairs few.

POA RIGIDA (Pl. 37. fig. 23). (See p. 334, above.)

‖‖ Chlorophyll-tissue normal. Hairs many.

CYNOSURUS CRISTATUS. Grantchester, Cambs. August 1900.

Ribs rounded and fairly prominent on both sides. Margin rounded. Bundles of three orders; larger ones have both sheaths well marked, but in smaller ones the inner sheath is not well seen. Stereome-bands above and below all bundles, and in two cases below the motor cells.

Melrose. June 1901.

As above, except that stereome is more abundant; it forms girders to all bundles below and to larger ones (except that in midrib) also above.

§§ Motor cells inconspicuous. A few asperities on both sides. Stomata more numerous above.

ANTHOXANTHUM ODORATUM. Roslin. 11th May, 1901.

Cells of neither epidermis very strongly cutinized. Vascular bundles not numerous. Stereome forms girders below to larger bundles, bands above and below in all cases.

PHLEUM PRATENSE, var. NODOSUM (Pl. 39. fig. 48). Chippenham, Cambs. August 1901.

Lower epidermal cells fairly strongly cutinized, upper less so. A very few short projections on epidermal cells. Bundles of three orders. Stereome forms half-girders below and bands above larger bundles; and bands above and below, or above only or below only, or none at smaller bundles.

** No hairs or asperities; surfaces smooth or at most slightly papillose.

† Stereome relatively abundant, and forming girders to some or all bundles. Motor cells between all the ribs, and conspicuous.

‡ Vascular bundles very numerous and large, and some of the motor-cell groups dipping more than halfway into the leaf-tissue. Stomata abundant both sides.

ARUNDO PHRAGMITES (Pl. 39. fig. 49). Cambs. July 1900.

Leaf-surfaces almost parallel. Leaf broad and rather thick. Epidermal cells small, fairly strongly cutinized on both sides of the leaf. Bundles numerous and large, of three orders. Outer sheath very conspicuous in all, but inner is much less so. Stereome strong; it forms girders to larger bundles on both sides and to some of the smaller ones below.

‡‡ Vascular bundles neither numerous nor large; motor-cell groups not a quarter so deep as the leaf-section. Stomata predominate above.

FESTUCA ELATIOR (Pl. 39. fig. 50). Fulbourn, Cambs. July 1900.

Ribs mostly rounded; the midrib the largest, others of various orders. Lower epidermal cells rather flatter than upper. Bundles of three orders, corresponding to ribs. Inner sheath not well marked, outer more so. Most of the bundles girdered at least to lower side; stereome-bands also above bundles.

†† Stereome relatively inconspicuous, and rarely or never forming complete girders. Motor cells between all ribs.

‡ Motor-cell groups conspicuous.

§ Motor-cell groups shallow and extended.

CYNOSURUS ECHINATUS (Pl. 39. fig. 51). Royal Botanic Garden, Edinburgh. July 1901.

Leaf rather thin. Ribs broad, rounded and low. Both upper and lower epidermal cells feebly cutinized and arched. Motor cells in broad bands, but individually not very distinct from the ordinary epidermal cells. Bundles of three orders, rather far apart. Sheaths not well marked. Stereome not abundant; it forms bands above and below most of the bundles, and girders below to larger ones.

[Not much information as to the relationship of leaf-structure to environment can be gained from a comparison of the two grasses; *C. cristatus* is a fairly typical meadow-grass; and although the leaf-structure of *C. echinatus* differs in many features from that of *C. cristatus*, not one of these can be regarded as an adaptation to its environment. In fact, from the leaf-structure one would almost certainly judge *Cynosurus echinatus* to be adapted to far more favourable conditions as to water-supply and transpiration than *C. cristatus*.]

§§ Motor-cell groups not shallow and wide.

PHLEUM ALPINUM (Pl. 39. fig. 52). Royal Botanic Garden, Edinburgh. April 1901.

Low ribs on upperside, some square, others rounded. Stomata rather more numerous above than below. The larger vascular bundles have bands above and below, to which they are joined by bands of colourless cells interrupting the chlorophyll-tissue; the other bundles may have bands of stereome above or below, or above and below, or none.

PHLEUM ARENARIUM. Yarmouth, Norfolk. May 1901.

Ribs low, square, and rounded. Lower side flat. Cells of neither epidermis strongly cutinized. Cells not flattened. Stomata abundant on both sides. Vascular bundles with conspicuous outer sheath, but in smaller bundles the inner sheath is not marked. Girders to larger bundles and small bands above and below smaller ones. Chlorophyll-tissue with slight tendency to be arranged in rings.

[Although we have in the genus *Phleum* representatives of four œcological groups, the structure of the leaf is very constant throughout. Taking the pasture-grass, *P. pratense,* as our standard for comparison, we see that the variety *nodosum,* which is characteristic of more exposed and sandy situations, is practically identical in leaf-structure, the only difference being that it shows a slightly greater difference between the upper and lower epidermis in the cutinization of the cells and the number of stomata. *P. alpinum,* again, is very similar in structure, differing only in its rather feebler stereome and in its thicker leaf; the latter feature is characteristic of alpine grasses. *P. arenarium,* although a sand-dune grass, has the leaf-structure practically identical with *P. pratense,* showing in this respect no adaptation to its environment.]

‡‡ Motor cells inconspicuous.

BRIZA MEDIA. Swanton Morley, Norfolk. June 1901.

Upper surface with fairly conspicuous ribs, some higher and rounded, others lower and square. Stomata on both sides. Vascular bundles few, larger ones in the lower ribs. Stereome-bands above and below bundles.

Fulbourn, Cambs. July 1900.

Stereome rather more abundant; midrib and one or two of the larger bundles girdered below. Otherwise the same as above.

PART III.

There remains to be considered the structure of grass-leaves from the point of view of their arrangement in groups according to habitat; to try to discover how far the leaf-structure is constant throughout an œcological group; and, if possible, to explain the characteristic leaf-structure of the grasses of a group as an adaptation to the environment, and to account for the exceptions. For this purpose I have divided the grasses whose leaf-structure I have examined into seven groups, as follows:—

i. Grasses of Meadows and Pastures.
ii. „ Waste and Sandy Places.
iii. „ Woods and Shaded Places.
iv. „ Maritime Sands.
v. „ Moors and Heaths.
vi. „ Wet Places.
vii. Alpine Grasses.

The distinctions between these groups are not very definite, and in nearly every group I have had to include grasses which might equally well, possibly better, have been included in one or other of the remaining groups.

In what follows, when speaking of a leaf-structure as typical, I merely mean to imply that this leaf-structure appears to me to be that which is best adapted to its environment.

i. *Grasses of Meadows and Pastures.*

Grass.	Duration.	Figure.
Festuca duriuscula	Perennial.	17
—— *rubra*	„	7
—— *elatior*	„	50
—— *pratensis*	„	—
Phleum pratense	„	46
Alopecurus pratensis	„	18
Anthoxanthum odoratum	„	—
Dactylis glomerata	„	—
Poa trivialis	„	—
—— *pratensis*	„	—
Briza media	„	—
Arrhenatherum avenaceum	„	—
Lolium perenne	„	—
—— *temulentum*	„	24
Hordeum pratense	„	40
Koeleria cristata	„	15
Agrostis stolonifera	„	—
—— *vulgaris*	„	—
—— ——, var. *pumila*	„	10
Hierochloë borealis	„	30
Cynosurus cristatus	„	—
Aira cæspitosa	„	20
Avena pratensis	„	28

With so large a number of species included in this group, it is inevitable that they should cover a great range of habitat; some of those included might almost equally well be placed in Group ii.; others are characteristic of wet meadows, others of shady meadows, others of cornfields, others of dry pastures, and so on. On the other hand, none of them are found in very dry, and none in very wet, situations.

Corresponding to this variety of habitat we get a fairly wide range of leaf-structure. Nevertheless, though there are no positive characters common to the group, there are many negative characters which will hold good throughout almost the whole of it.

On the whole, then, the leaf-structure of the grasses of this group is not a highly specialized one; and this fact renders it of importance, because the leaf-structure of other groups can with advantage be compared with it.

In form, the leaf-section varies from that of the two species of *Poa*, with the upper and lower surfaces perfectly flat and parallel, to that of *Aira cæspitosa*, with the upper surface thrown into extraordinarily high ridges. The latter grass is, however, exceptional in this respect, and only a few leaves have the perfectly smooth surfaces of *Poa trivialis* and *P. pratensis*; the great majority of the grasses of this group have leaves in which the upper surfaces possess a number of low, rounded ribs. In most cases these ribs are extremely low, indeed practically obsolete, but in a fair number the thickness of the leaf at the ribs rises to be double that at the grooves; this is the case, for instance, in *Festuca duriuscula* and *F. rubra* and in *Koeleria cristata*. As will be seen, however, from a glance at the figures, we get all intermediate stages between these leaves and those where the upper surface is practically smooth. The majority of the leaves are not markedly hairy; in a good many, however (Pl. **39.** fig. 46, Pl. **37.** fig. 24, &c.), we find a small number of short hairs or asperities, either confined to one side or occurring on both; moreover, in *Festuca duriuscula* (Pl. **37.** fig. 17), and in one specimen of *Koeleria cristata*, we find that the leaf-surface (or surfaces) is covered with numerous long hairs; both these grasses occur in rather dry pastures, and the hairs may thus be a protection against excessive transpiration. Against this explanation must be set the fact that the leaf of *Koeleria cristata* (Pl. **36.** fig. 15), from the dry sandy pastures of Gullane, is conspicuously less hairy than that taken from a plant cultivated under much moister conditions in the Royal Botanic Garden at Edinburgh.

Again, in the majority of these leaves stomata are found both on the upper and on the lower surface; however, in most of the leaves the stomata occur in greater abundance on the upper than on the lower side, and in *Festuca duriuscula* there are no stomata on the lower side of the leaf—another point in which this grass is seen to possess the most xerophytic leaf-structure of the group.

Generally the cells of the lower epidermis are more strongly cutinized than those of the upper, but in the majority of cases the difference is not marked. Here, again, *Festuca duriuscula* is an exception; so, also, are *F. rubra* and *Koeleria cristata*, as in their leaves the difference between upper and lower epidermis is great.

The leaves are never specially broad or narrow, neither exceptionally thick nor thin. The vascular bundles are never very numerous, nor are they ever very few; the smallest number of bundles are found in the upper leaves of *Festuca rubra*.

. . . . . .

The mechanical tissue is never very scanty, in most cases it is fairly abundant; it generally forms girders or moderately strong bands above and below, at least, the larger vascular bundles. There is usually no very marked difference in the amount of stereome present in the upper and lower halves of the section; in *Festuca duriuscula* and in *F. rubra*, however, the stereome is considerably more abundant in the lower half of the leaf-section.

The leaf is folded in *Poa trivialis* and *P. pratensis*, *Avena pratensis* (Pl. **37**. fig. 28), and *Dactylis glomerata* (Pl. **38**. fig. 31); in all other cases it is rolled.

ii. *Grasses of Waste and Sandy Places.*

Grass.	Duration.	Figure.
Festuca Myuros	Annual.	—
—— ——, var. *bromoides*	"	—
Phleum pratense, var. *nodosum*	Perennial.	48
Alopecurus agrestis	Annual.	—
Holcus mollis	Perennial.	42
—— *lanatus*	"	43
Bromus sterilis	Annual.	27
—— *mollis*	"	—
—— *erectus*	Perennial.	—
Poa compressa	"	—
—— *annua*	Annual.	—
—— *rigida*	"	23
Setaria viridis	"	36
Hordeum murinum	"	—
Agrostis Spica-venti	"	22
Aira præcox	"	5
—— *caryophyllea*	"	—
Agropyrum repens	Perennial.	—
Lagurus ovatus	Annual.	44

It is interesting to notice in the above table what a large proportion of these grasses are annuals, only six out of the nineteen grasses I have collected being perennial, while of the twenty-three pasture- and meadow-grasses examined not one is an annual.

As in the last group, the various forms included here cover a fairly large range of habitat. A number of forms included here are common to this group and to Group i., others are found on dry banks, others on old walls &c. On the whole, however, the grasses occur in drier situations than do the meadow- and pasture-grasses; none are found in wet places, while in many cases the habitat is distinctly xerophilous.

When, however, we come to examine the leaf-structure, we find very little difference between these and the meadow-grasses, not nearly so much as would correspond with the difference in habitat.

Apart from *Aira præcox* and *A. caryophyllea* the form of the leaf-section is very uniform; they all show the upper surface of the leaf either perfectly smooth or with low rounded ribs. The ribs are most prominent in *Festuca bromoides*; in the great majority of cases they are practically obsolete.

As in the meadow-grasses, stomata usually occur on both sides of the leaf, and generally they are more abundant on the upperside. Again, the cells of the lower epidermis are very often more strongly cutinized than those of the upper, though usually the difference is not a very marked one. These differences are fairly well marked in *Festuca Myuros* and *F. bromoides,* but certainly not more so than in *F. duriuscula* among pasture-grasses.

A certain number of the leaves are very hairy (Pl. 39. fig. 43; Pl. 37. fig. 27), and this may be regarded as a protection against excessive transpiration, also perhaps against the smothering of the leaves with dust. But this feature is by no means a general one, and is, in fact, hardly more common here than in the meadow-grasses.

As in meadow-grasses, again, the leaf is usually not markedly broad or narrow, thick or thin. The stereome is arranged, as in meadow-grasses, in bands or girders above and below the vascular bundles, and it is, generally speaking, neither more nor less abundant than in pasture-grasses. In *Festuca Myuros* the stereome is not abundant, and it is confined to the lower side of the leaf; this indicates a slight transition to the heath-grass "type" of leaf, but it is not more marked than in *F. duriuscula.*

Certain grasses of this group show various exceptional features in their leaf-structure which may perhaps be mentioned here.

Setaria viridis certainly possesses the most exceptional leaf-structure of all the grasses I have examined. The enormous epidermal cells and the great number of small vascular bundles are both features peculiar to this grass; the small amount of stereome is also exceptional, while the arrangement of the chlorophyll-cells in rings around the bundles is met with in only a few other British grasses; the last feature, as has been noted above, is probably a xerophilous character.

Poa rigida also possesses this peculiar type of chlorophyll-tissue.

Aira præcox and *A. caryophyllea* are noteworthy on account of the extreme smallness of their leaves; they both inhabit very dry situations, and this smallness of the leaf is in itself a xerophilous adaptation, rendering any change in the leaf-structure unnecessary. The leaf-sections may perhaps be described as of a reduced type of that of a heath-grass. The general feebleness of the tissues is directly dependent upon the reduced size of the leaf.

iii. *Grasses of Woods and Shaded Places.*

Grass.	Duration.	Figure.
Melica uniflora	Perennial.	32
—— *nutans*	”	—
Bromus asper	Annual or Perennial.	26
—— *giganteus*	Perennial.	—
Poa nemoralis	”	—
Milium effusum	”	35
Brachypodium sylvaticum	”	—

The conditions under which these wood-grasses naturally grow are decidedly less favourable to transpiration than those under which either meadow or waste-place grasses are found. On the other hand, there is no excessive supply of water, nor is there any difficulty as regards aeration, such as is suffered by the grasses of wet places. The conditions for illumination, however, are not so favourable.

When we examine the leaf-structure of the grasses of this group, we find that it is fairly uniform, and it is one that is quite well adapted to such conditions as mentioned above.

In the first place, the leaves are all distinctly thin in comparison with their breadth: in the figures this is best seen in *Melica nutans*, *M. uniflora* (Pl. 38. fig. 32), *Poa nemoralis*, and *Brachypodium sylvaticum*, but the feature is quite a constant one, the figure in the other cases showing only a small part of the leaf-section, so that the relative breadth and thickness of the leaf cannot be judged. This feature, of course, is an adaptation to favour transpiration and to secure as much illumination for the leaves as is possible in their shaded habitat.

The ribs on the upper surface of the leaf are either entirely absent, as in *Poa nemoralis* and *Melica uniflora* (Pl. 38. fig. 32), or they are practically obsolete, as is the case in all the other members of the group. Stomata, again, are generally fairly abundant on both sides of the leaf, though in most cases they are more abundant on the upper than on the lower side. Moreover, the cells of both the upper and the lower epidermis are only feebly cutinized, those of the lower being rather more strongly so than those of the upper. These features all tend to favour transpiration, or perhaps it is better to say that there is an absence of all those structural features which in other grass-leaves tend to reduce transpiration.

Hairs occur abundantly on the upper leaf-surfaces of *Melica nutans* and *Brachypodium sylvaticum*. It is difficult to understand their significance; they can hardly be regarded here as a xerophilous feature.

The stereome is fairly strong, in most cases the larger vascular bundles are girdered at least to the lower side, while often even the smaller bundles are girdered to one or to both sides of the leaf (Pl. 37. fig. 26). In *Melica uniflora* most of the bundles are not girdered, but, as they all have fairly strong bands of stereome above and below, the point is not of importance. This strength of the mechanical tissue is in all probability a direct outcome of the thinness of the leaf and its general softness, these characters rendering a well-developed supporting system necessary.

The motor cells in nearly every case are arranged in very broad bands—in some cases they are well marked off from the ordinary epidermal cells, in others they are hardly conspicuous.

In *Brachypodium sylvaticum* the cells of the lower epidermis are strongly cutinized and their outer surfaces are flat. These are points in which the leaf of this grass differs from that of every other member of the group.

iv. *Grasses of Maritime Sands.*

Grass.	Duration.	Figure.
Festuca elatior, var. *arundinacea*	Perennial.	11
Hordeum maritimum	Annual.	16
Cynosurus echinatus	,,	51
Agropyrum junceum	Perennial.	13
Psamma arenaria	,,	12
Mibora verna	Annual.	1
Elymus arenarius	Perennial.	9, 14
Bromus maximus	Annual.	41
Poa bulbosa	Perennial.	47
—— *loliacea*	Annual.	—
Phleum arenarium	,,	—
Lepturus filiformis	,,	8

Among all these grasses the leaf-structure can only be described as "typical" in three —*Psamma arenaria*, *Agropyrum junceum*, and *Elymus arenarius* (Pl. 36. figs. 9, 12, 13, 14); of these *Psamma arenaria* shows the most highly specialized leaf-structure.

The habitat of these grasses is pronouncedly xerophytic; the water-supply is small and very variable, while the conditions are extremely favourable to rapid transpiration. Moreover, the leaves, and especially the large ones, are often subjected to great mechanical strain.

Corresponding to this we find the leaf-structure of the three grasses mentioned to be of a strongly xerophilous type.

The leaf is broad, thick, and hard in consistency: the upperside is provided with high well-marked ribs; in *Psamma arenaria* and in *Agropyrum junceum* the ribs are covered with numerous rather short hairs. The stomata are confined to the flanks of the ridges, where they are well shut in and are, moreover, further protected by the hairs. Again, the cells of the lower epidermis are very strongly cutinized and their outer surfaces are quite flat; the cells of the upper epidermis are quite strongly cutinized, though not so strongly as those of the lower. These features, then, secure in the first place the complete restriction of the transpiring surface to the flanks of the ridges, and in the second place the protection of this restricted area by sheltering the stomata from air-currents. The groups of motor cells at the bottom of the grooves are not at all conspicuous; we cannot, therefore, judge of the activity of these cells by their prominence in sections.

The vascular bundles are large and possess conspicuous inner and outer sheaths; the inner sheath is particularly well marked in the larger bundles. The bundles are probably capable of conducting large supplies of water after rains.

The stereome is extremely strong and abundant, the bundles are strongly girdered at least to the lower side, and in *Psamma arenaria* and *Agropyrum junceum* we get a strong subepidermal layer of stereome on the lower side of the leaf; this is not met with in the leaf of *Elymus arenarius*, except just at the tip. The amount and arrangement of the stereome can, I think, as I have shown above, be explained on purely mechanical grounds.

Poa bulbosa differs in almost every respect from the typical leaf-structure. Though a perennial grass, the green subaerial parts are short-lived, lasting only a few weeks in spring, so that the leaves do not have to withstand such strongly xerophilous conditions as do those of our types; moreover, the leaves are rather small, short, and narrow—characteristics which tend to reduce transpiration. However, the cells of the lower epidermis are strongly cutinized and the stomata are to a large extent confined to the upperside of the leaf. The small amount of stereome is dependent upon the small size of the leaf.

Festuca arundinacea is to some extent intermediate in leaf-structure between our typical maritime grasses and heath-grasses. The well-marked ribs covered with hairs and the strong subepidermal stereome are maritime characters. In its narrowness, in the absence of girders to the bundles, and in the small amount of stereome in the upper half of the leaf, the leaf-section resembles that of a heath-grass. The strong cutinization of the lower epidermal cells and their flat outer sides, and the absence of stomata from the upperside, are features common to both groups. In every respect, however, the leaf-section is of a distinctly xerophilous type.

Lepturus filiformis is an annual, but its leaf-structure shows marked xerophilous characters. These, however, are much more like those met with in the leaves of heath-grasses than in those of the typical maritime ones—in fact, the leaf-structure is quite that of a typical heath-grass. The increase in size of the midrib relatively to the other ribs giving rise to a subulate leaf, the absence of girders to the bundles, and the massing of the stereome under the lower epidermis are all characters of heath rather than of maritime grasses, though there is rather more stereome than is usual in the heath type of leaf. The strong cutinization of the lower epidermal cells, the absence of stomata from the lower side, and the hairiness of the upperside are characters common to both the heath and the maritime type. The arrangement of the chlorophyll-tissue in rings about the bundles is a feature shared with a few other grasses (*Setaria viridis*, *Poa rigida*), all more or less xerophytic in habitat; and, as explained above, it is probably a xerophilous modification.

Poa loliacea is also an annual. The leaf-structure is more or less of a xerophilous character, but not so markedly as that of a typical maritime grass. The chief xerophilous features are the cutinization of the epidermal cells, the absence of stomata from the lower side of the leaf, and the arrangement of the chlorophyll-tissue in rings round the bundles. It departs from the maritime type conspicuously in the small amount of stereome present, also in the smaller size of the leaf, the less marked ribs on the upperside, and the feebler cutinization of the cells of the epidermis. Its habitat is not that of a typical maritime sand-grass, and perhaps it had better have been placed in Group ii. by the side of *Poa rigida*, to which it is closely allied.

The remaining grasses of this group are all annuals, and the leaves of none exhibit any structural features that can be described as adaptive.

Mibora verna, as already mentioned, is interesting as showing the most reduced leaf-structure among British grasses. This is to be explained by the short vegetative period of the plant and the smallness of the leaf, the latter itself being a xerophilous character.

Cynosurus echinatus is a rare grass in Britain, and I have not been able to obtain it from its natural habitat. The leaf-structure is practically that of a typical wood-grass (compare Pl. **39.** fig. 51 with Pl. **38.** fig. 32 &c.). We get a thin broad leaf, obsolete ribs on the upperside, feeble cutinization of the epidermal cells, stomata present on both sides, and broad bands of motor cells. I am unable to give any satisfactory explanation that will account for such a leaf-structure in a maritime sand-grass.

Practically the same may be said of *Bromus maximus*, another rare grass in Britain. It may, however, be recalled that the leaf-structure is very constant throughout the genus *Bromus*.

Hordeum maritimum and *Phleum arenarium* are both small plants, with a short vegetative period and very short leaves. It need not surprise us therefore to find that neither shows any xerophilous characters in the structure of the leaf.

v. *Grasses of Moors and Heaths.*

Grass.	Duration.	Figure.
Festuca ovina	Perennial.	3, 4
Nardus stricta	"	2
Agrostis canina	"	19
Triodia decumbens	"	34
Molinia cærulea	"	29
Aira flexuosa	"	6

The typical heath-grasses live under conditions which are most decidedly xerophytic, are generally found in places where they have no shelter, and are constantly exposed to high dry winds and to the sun, where consequently the conditions for rapid transpiration are most favourable, and where also the water-supply is limited.

In agreement with this, we find that the typical leaf-structure is perhaps the most pronouncedly xerophytic met with in British grasses; certainly it differs more markedly from the meadow-grass type more than does any other.

Three out of the six grasses of this group, which I have examined, possess this "typical" leaf-structure. These are *Festuca ovina* (Pl. **36.** figs. 3, 4), *Nardus stricta* (fig. 2), and *Aira flexuosa* (fig. 6); and of these *Aira flexuosa* possesses the most highly modified leaf-structure. To these, so far as structure goes, might be added the leaf of *Lepturus filiformis* (fig. 8).

The leaf is subulate, the upper surface being reduced to a mere channel in what is practically a solid leaf. I have already attempted to trace the evolution of this type of leaf from the more usual type with a large upper surface. By assuming this form the leaves offer as small a surface for the cubic contents as is possible.

The cells of the lower epidermis are very strongly cutinized and have their outer walls flat. Stomata are entirely absent from this lower epidermis. These two features, of course, render the amount of transpiration that takes place from the lower epidermis quite a negligible quantity.

The fold which represents the upper surface of the leaf is covered with numerous short hairs; these and the position of the stomata on the sides of the fold shelter the stomata from winds, and so reduce the transpiration, even on the restricted area where it is possible, to a minimum.

The vascular bundles are few; there is generally one large central bundle in the enlarged midrib and one or two smaller lateral bundles.

The stereome is, as a rule, not abundant; there is a tendency for it to be much stronger on the lower than on the upper side of the leaf, and for it to take the form of small subepidermal bands rather than of girders to the bundles; this is least well seen in *Nardus stricta*, where the bundles are girdered to the lower side of the leaf. This arrangement of the stereome is that which is mechanically most advantageous in a subaerial cylindrical organ.

Agrostis canina differs considerably from the above type in its leaf-structure. The leaf is not subulate, and the upper surface is marked with ribs and grooves; stomata are present on both sides, though they are more abundant on the upper; the cells of both upper and lower epidermis are strongly cutinized, and the arrangement of the stereome is that common in flat leaves. On the whole, therefore, the leaf-structure is quite of the type characteristic of pasture- and meadow-grasses, and the grass is characteristic rather of wet peaty places than of dry heaths, and it is therefore not surprising that its leaf-structure differs from that of the true heath-grasses.

Molinia cærulea again is characteristic of wet heaths. The most peculiar feature in its leaf-structure—the large air-lacunæ in and near the midrib—is thus accounted for by the need of efficient aeration. It shows, however, xerophilous adaptation in the small, strongly cutinized, epidermal cells, and it is also peculiar in the great strength as well as abundance of the mechanical tissue. The peculiar broadening out of the lower stereome-girder to the bundle in the midrib is probably due to the weakening of the leaf here by the development of the air-lacunæ. On the whole, then, this grass would be better described as a marsh xerophyte than as a heath-grass.

Triodia decumbens, on the other hand, is, so far as habitat goes, a true heath-grass; though it is also found in wet, barren land. In its leaf-structure it differs very widely from our types, but it cannot be referred to any other group. The leaf-section shows marked xerophytic characters in the thickness and cartilaginous texture of the leaf, in strong cutinization of the lower epidermal cells, in the stomata being more abundant on (though not confined to) the upper surface of the leaf, and perhaps in the small, closely-packed, chlorophyll-containing cells. The stereome is also specially strong and fairly abundant. So far as leaf-structure goes, then, *Triodia* may be regarded as a heath-grass, with another, not so highly modified, type of leaf-section.

vi. *Grasses of Wet Places.*

Grass.	Duration.	Figure.
Alopecurus geniculatus	Perennial.	21
Catabrosa aquatica	„	38
Glyceria fluitans	„	39
—— *aquatica*	„	37
Digraphis arundinacea	„	45
Arundo Phragmites	„	49

To these grasses, *Aira cæspitosa* from wet meadows might perhaps be added. Its leaf-structure is exceptional for any group of grasses, but it shows some resemblances in this to *Alopecurus geniculatus*.

The conditions under which these grasses grow may easily be described: the water-supply is abundant, and they are sheltered on the banks of streams, &c., from rapid transpiration. As in most water-plants, the conditions are not favourable for aeration.

The two species of *Glyceria* (Pl. 38. figs. 37, 39) show perhaps the most typical leaf-structure. The modifications from the meadow type all tend to secure more rapid transpiration and more efficient aeration. We get, then, a large leaf, broad and long, with both surfaces flat or nearly so, while the stomata are abundant and about equally numerous on the two sides: these characters all favour transpiration.

Owing to their sheltered situations the stereome is not abundant; the numerous small supernumerary bands of stereome in the leaf of *G. aquatica* serve to support those parts of the leaf which contain the large air-lacunæ. The lacunæ themselves serve, of course, to facilitate aeration.

Of the others, *Catabrosa aquatica* is quite typical in leaf-structure except for the absence of large air-spaces; this, however, is partly compensated for by the very loose and spongy arrangement of the mesophyll-cells. Like that of *Glyceria fluitans* (Pl. 38. fig. 39), the cells of the upper epidermis are papillose.

The reed-grasses *Digraphis arundinacea* and *Arundo Phragmites* differ chiefly in the large amount and strength of the stereome present in the leaf. They are tall grasses and their broad leaves are therefore much exposed to the wind; that is, to mechanical strain, as may easily be seen by watching a clump of either of these grasses in a light wind. The absence of lacunæ is probably dependent upon the same fact; by the greater exposure of the leaves more efficient aeration is obtained; moreover, the presence of large lacunæ would perhaps render the leaf too liable to be torn.

Alopecurus geniculatus differs mainly in the presence of high well-marked ribs on the upperside of the leaf. These occur even more strikingly in *Aira cæspitosa*, and it is very difficult to understand their significance. It may be noted that the grooves between the ribs are much wider here than they are in the leaves of the maritime sand-grasses. Large air-lacunæ, again, are not present in *Alopecurus geniculatus*, but in all other respects the leaf-section agrees with types.

vii. *Alpine Grasses.*

Grass.	Duration.	Figure.
Phleum alpinum	Perennial.	52
Alopecurus alpinus	”	25
Poa alpina	”	33
——— ———, var. *vivipara*	”	—
Poa nemoralis, var. *Balfourii*	”	—
Avena alpina	”	—

The leaf-structure of the grasses of this group possesses the distinction of being the less adapted to its environment than is that of any other of our œcological groups.

The leaves show none of the features which are usually regarded as characteristically alpine, such as hairiness, smallness (in connection with the stunted habit of the plant), &c. The one feature that the leaves possess in common is that they are usually rather thick.

The fact that the leaves have undergone practically no modification in structure to fit them for their environment has already been shown in the second part of this paper. We have there seen that *Phleum alpinum* has practically the same leaf-structure as *P. pratense* (compare Pl. 39. figs. 46 & 52), that the leaf of *Alopecurus alpinus* has a structure very similar to that of *A. geniculatus* (Pl. 37. figs. 21 & 25), that *Poa alpina*, *P. vivipara*, and *P. nemoralis*, var. *Balfourii*, have the same leaf-structure as *Poa pratensis* and *P. annua*, and that the leaf-structure of *Avena alpina* and *A. pratensis* is practically identical. It is thus quite clear that in the change from a lowland to an alpine environment, no modification of leaf-structure (or practically none) has taken place.

In conclusion, I have to express my thanks to Professor Marshall Ward, who first interested me in this work—not only for this, but also for his advice throughout the research; and to Mr. J. Lewton-Brain, Mr. R. H. Yapp, and Mr. H. A. Denham, for specimens of grasses from different parts of the country.

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EXPLANATION OF THE PLATES.

FIGURES 1 to 52. Diagrams of transverse sections of leaves, outlines with the camera lucida and magnified about 60 diameters. The crossed lines represent stereome; circles with dots, vascular bundles; crescents with perpendicular lines, motor cells; black spaces, air-lacunæ; the epidermis is represented by a single line.

PLATE 36.

Fig. 1. *Mibora verna.*
2. *Nardus stricta.*
3. *Festuca ovina.*
4. The same.
5. *Aira præcox.*
6. *A. flexuosa.*
7. *Festuca rubra.*
8. *Lepturus filiformis.*
Fig. 9. *Elymus arenarius.*
10. *Agrostis vulgaris*, var. *pumila.*
11. *Festuca elatior*, var. *arundinacea.*
12. *Psamma arenaria.*
13. *Agropyrum junceum.*
14. *Elymus arenarius.*
15. *Koeleria cristata.*
16. *Hordeum maritimum.*

PLATE 37.

Fig. 17. *Festuca duriuscula.*
18. *Alopecurus pratensis.*
19. *Agrostis canina.*
20. *Aira cæspitosa.*
21. *Alopecurus geniculatus.*
22. *Agrostis Spica-venti.*
Fig. 23. *Poa rigida.*
24. *Lolium temulentum.*
25. *Alopecurus alpinus.*
26. *Bromus asper.*
27. *B. sterilis.*
28. *Avena pratensis.*

PLATE 38.

Fig. 29. *Molinia cærulea.*
30. *Hierochloë borealis.*
31. *Dactylis glomerata.*
32. *Melica uniflora.*
33. *Poa alpina.*
34. *Triodia decumbens.*
Fig. 35. *Milium effusum.*
36. *Setaria viridis.*
37. *Glyceria aquatica.*
38. *Catabrosa aquatica.*
39. *Glyceria fluitans.*
40. *Hordeum pratense.*

PLATE 39.

Fig. 41. *Bromus maximus.*
42. *Holcus mollis.*
43. *H. lanatus.*
44. *Lagurus ovatus.*
45. *Digraphis arundinacea.*
46. *Phleum pratense.*
Fig. 47. *Poa bulbosa.*
48. *Phleum pratense*, var. *nodosum.*
49. *Arundo Phragmites.*
50. *Festuca elatior.*
51. *Cynosurus echinatus.*
52. *Phleum alpinum.*

PLATE 40.

Fig. 53. Part of upper epidermis (*ep.*[1]) of *Festuca ovina*. (Camera lucida, × 250.)

54. Part of lower epidermis (*ep.*[2]) of the same leaf, showing also subepidermal stereome (*st.*). (C. l., × 250.)

55. Part of upper epidermis of leaf of *Lolium temulentum*.

56. Part of lower epidermis of same leaf. (C. l., × 250.)

57. Motor cells (*m.*) from same leaf as figs. 55 and 56. (C. l., × 250.)

58 & 59. Cells of upper and lower epidermis from leaf of *Triodia decumbens*. Fig. 58 shows also the small mesophyll-cells. (C. l., × 250.)

60 & 61. Cells of upper and lower epidermis from leaf of *Mibora verna*. (C. l., × 250.)

62. The same from leaf of *Festuca duriuscula*, showing also a group of stereome-cells. (C. l., × 250.)

63. Papillose cells from upper epidermis from the leaf of *Glyceria fluitans*. (C. l., × about 250.)

64. Part of upper epidermis of the leaf of *Nardus stricta*, showing hairs. (C. l., × 250.)

65. Part of transverse section of leaf of *Setaria viridis* (*mes.*, mesophyll; *o.s.*, outer bundle-sheath). (C. l., × 250.)

66. The same of *Hierochloë borealis* (*stom.*, stoma). (C. l., × 250.)

67. Part of transverse section of leaf of *Aira cæspitosa*, showing motor cells underlying colourless cells and band of stereome. The green mesophyll-cells are shaded. (C. l., × 250.)

68. Marginal band of stereome from leaf of *Avena alpina*. (C. l., × 250.)

69. Vascular bundle of first order from the leaf of *Festuca pratensis* (C. l., × about 300) (*i.s.*, inner bundle-sheath; *xy.*, xylem-vessels).

70. Vascular bundle of second order from leaf of *Elymus arenarius*. (C. l., × about 300.)

71. Vascular bundle of third order from leaf of *Agropyrum repens*. (C. l., × about 300.)

72. Part of transverse section of leaf of *Poa rigida*, to show arrangement of mesophyll-cells. (C. l., × about 250.)

73. Transverse section of leaf of *Milium effusum*. (C. l., × 250.)

74. Longitudinal section of leaf of same, to show mesophyll. (C. l., × 250.)

75. The same of *Hierochloë borealis*, showing also motor cells. (C. l., × 250.)

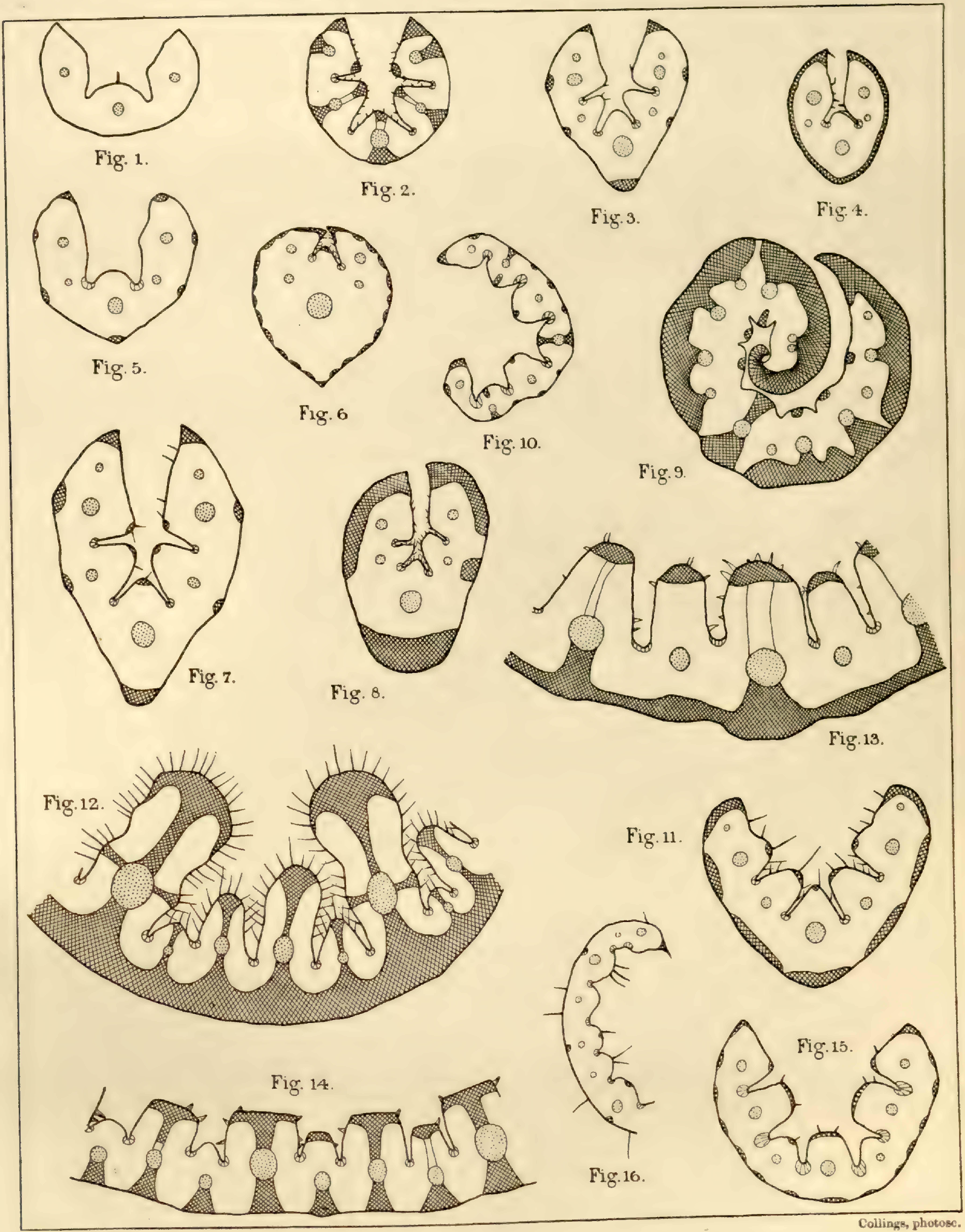
Fig. 1.
Fig. 2.
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Fig. 7.
Fig. 8.
Fig. 13.
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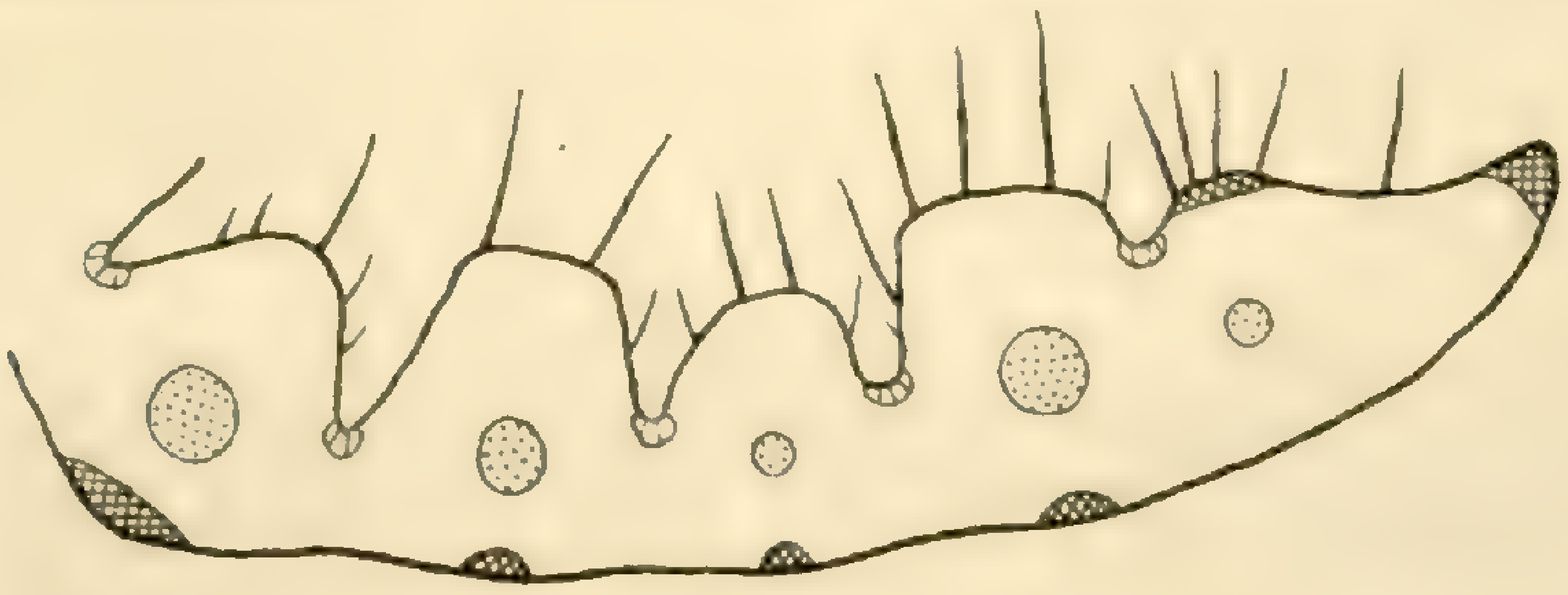
Fig. 16.
Fig. 15.

Lewton-Brain, del. Collings, photosc.

LEAVES OF BRITISH GRASSES.



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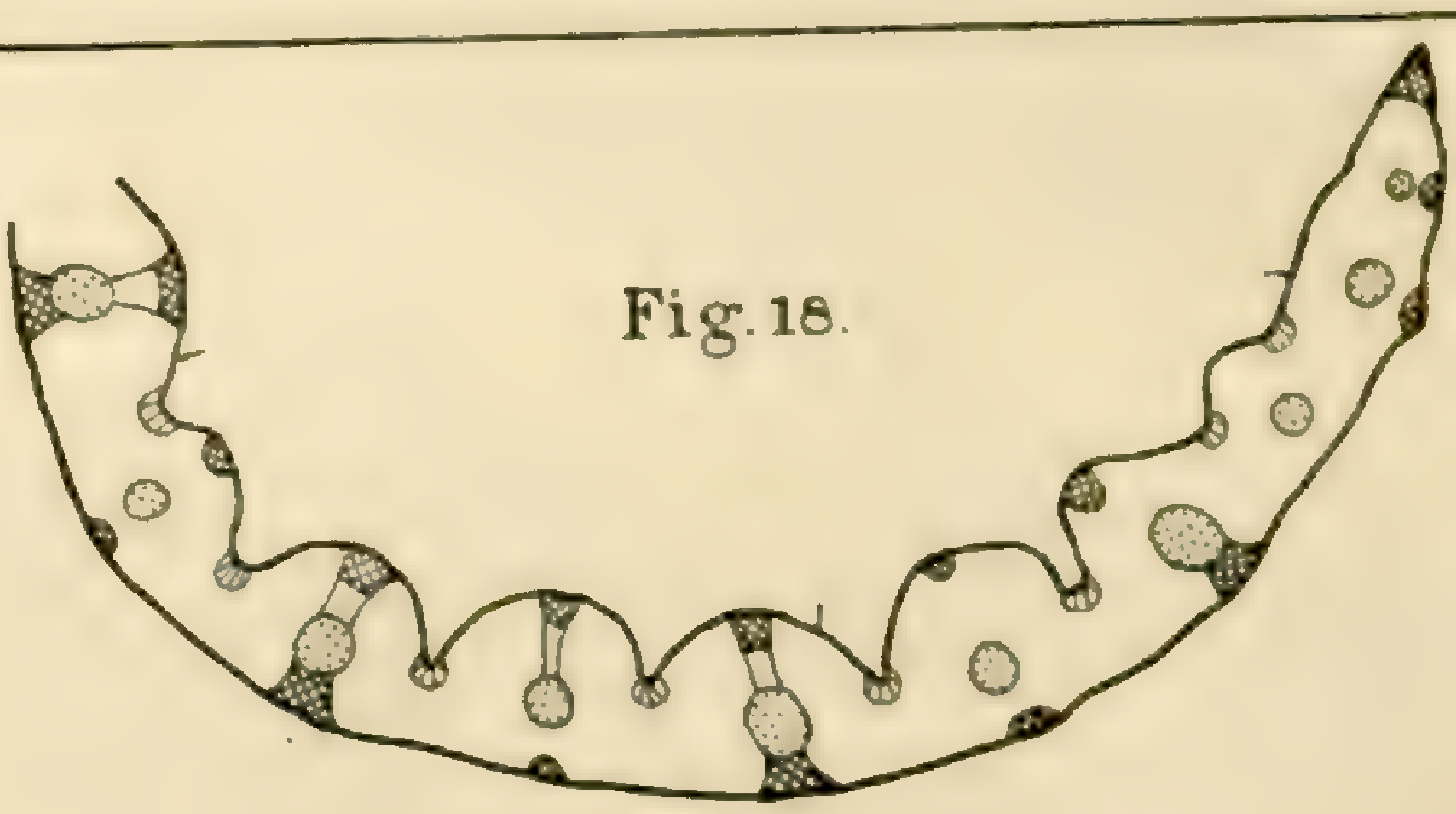

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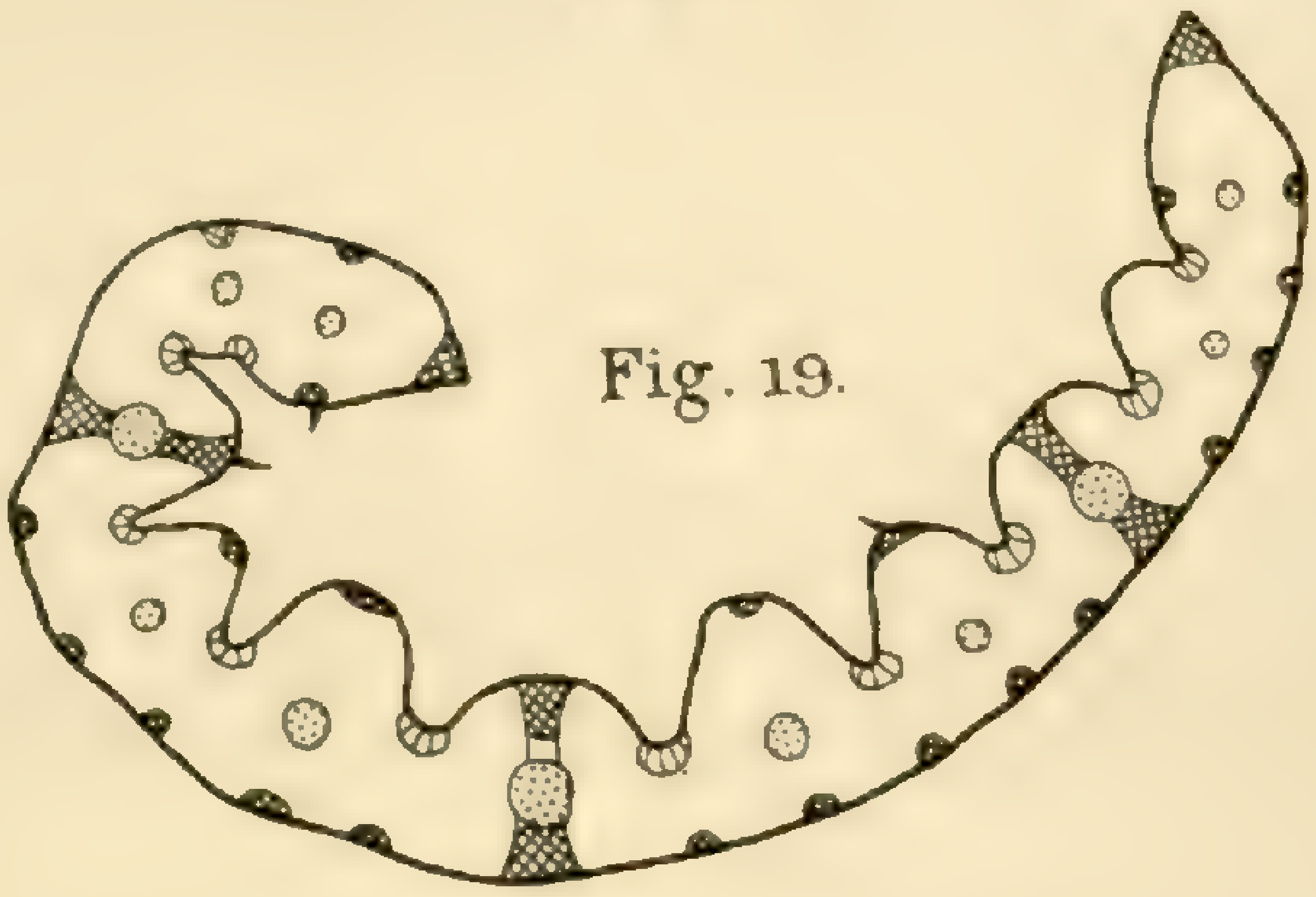

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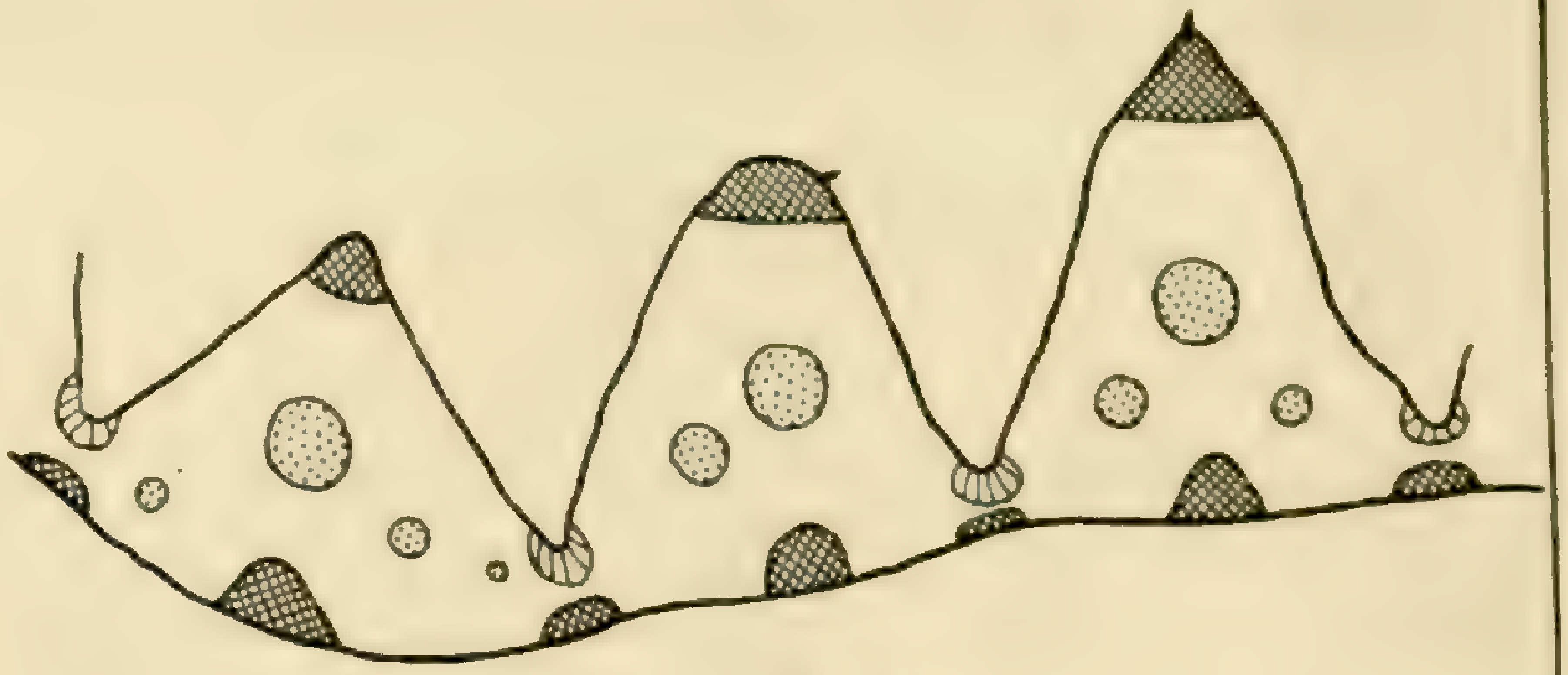

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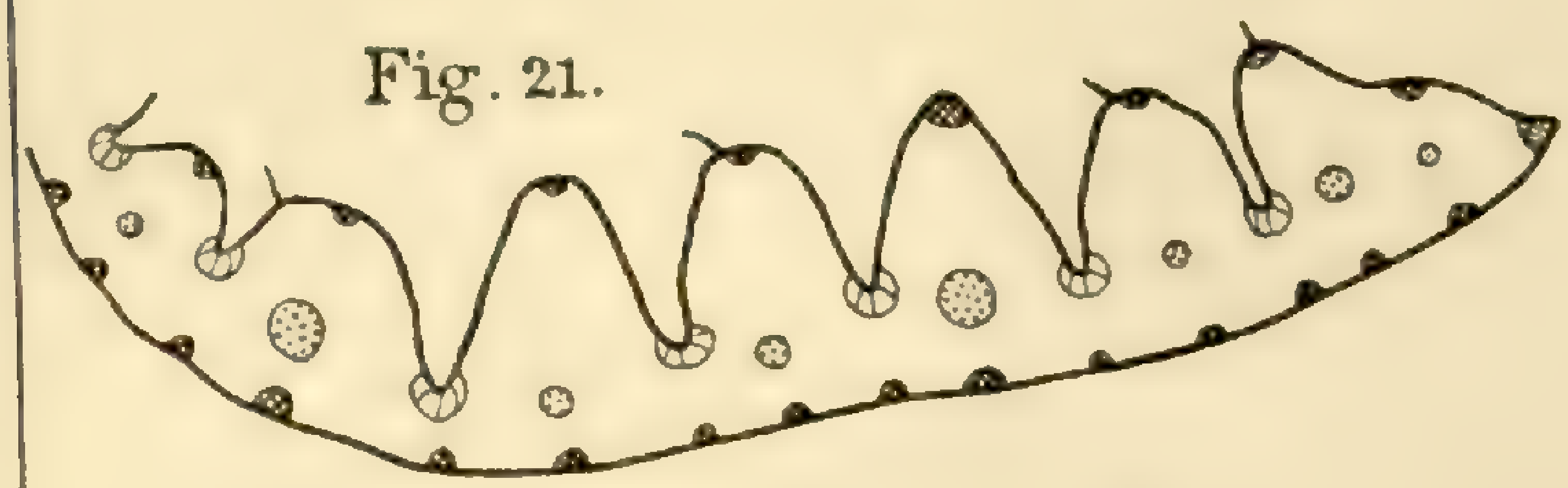

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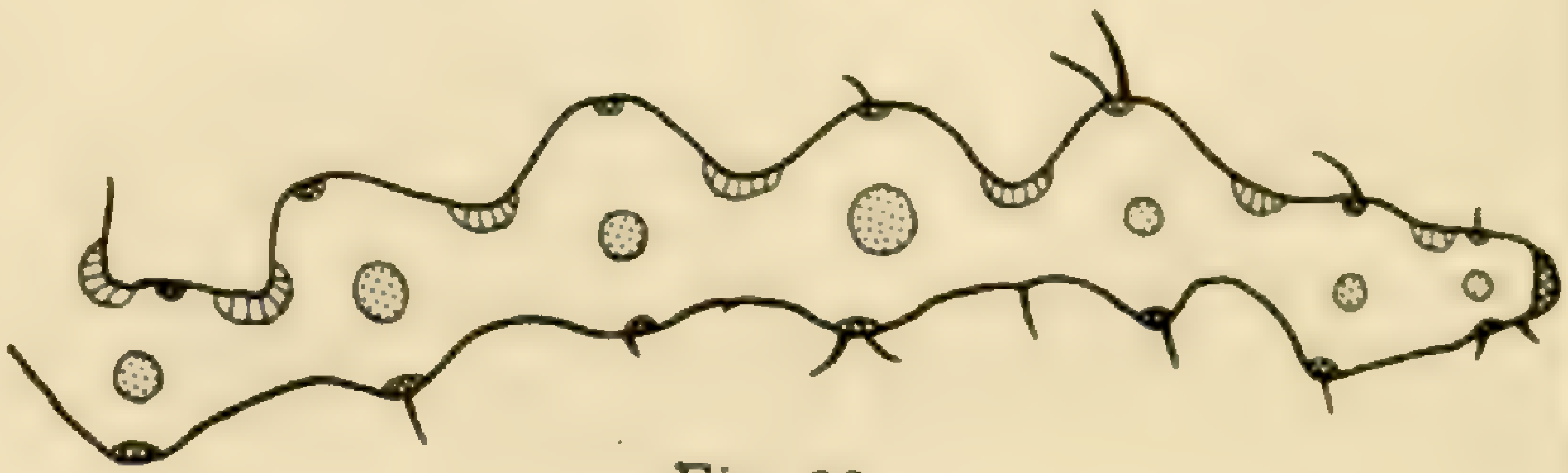

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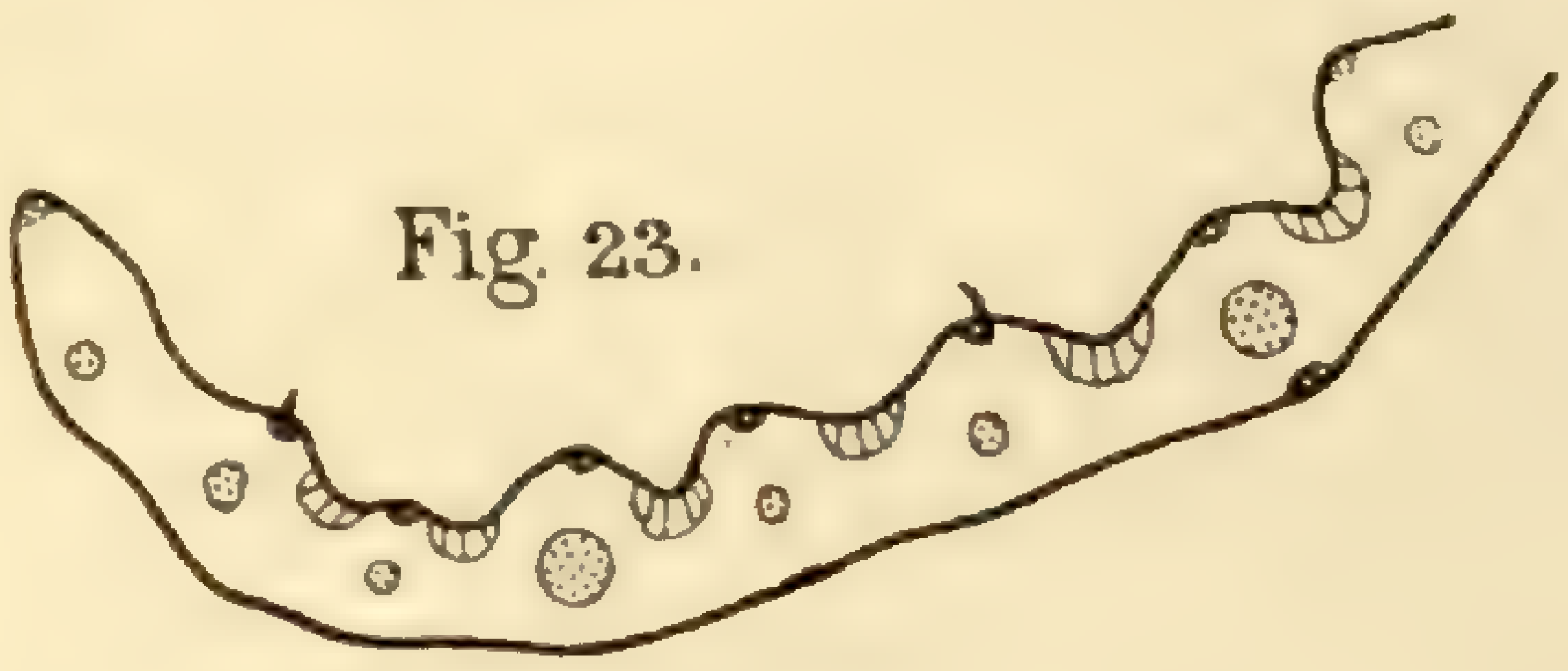

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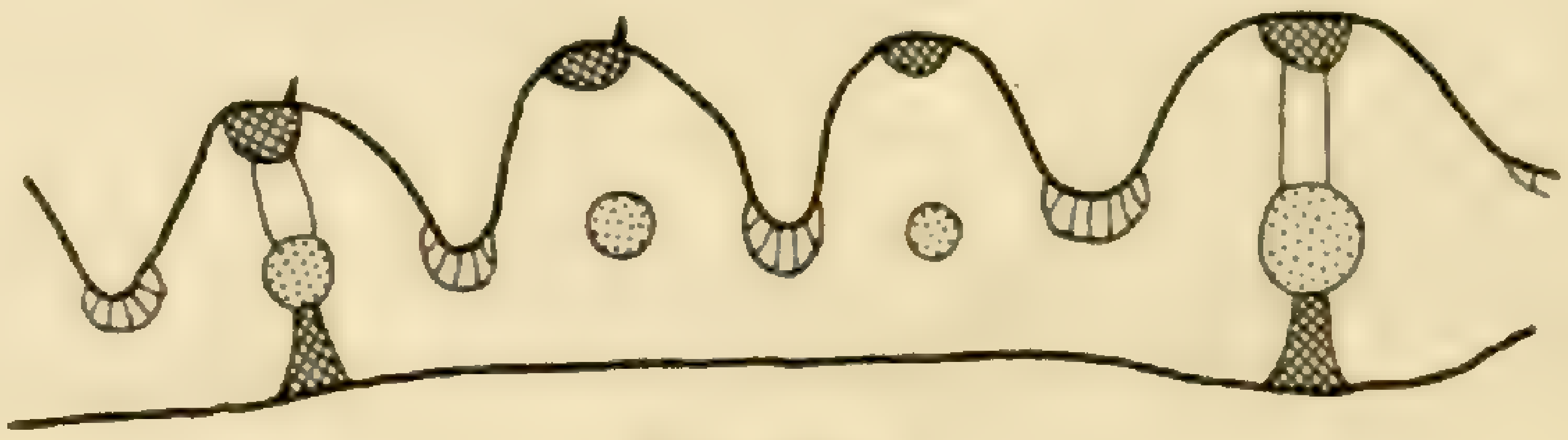

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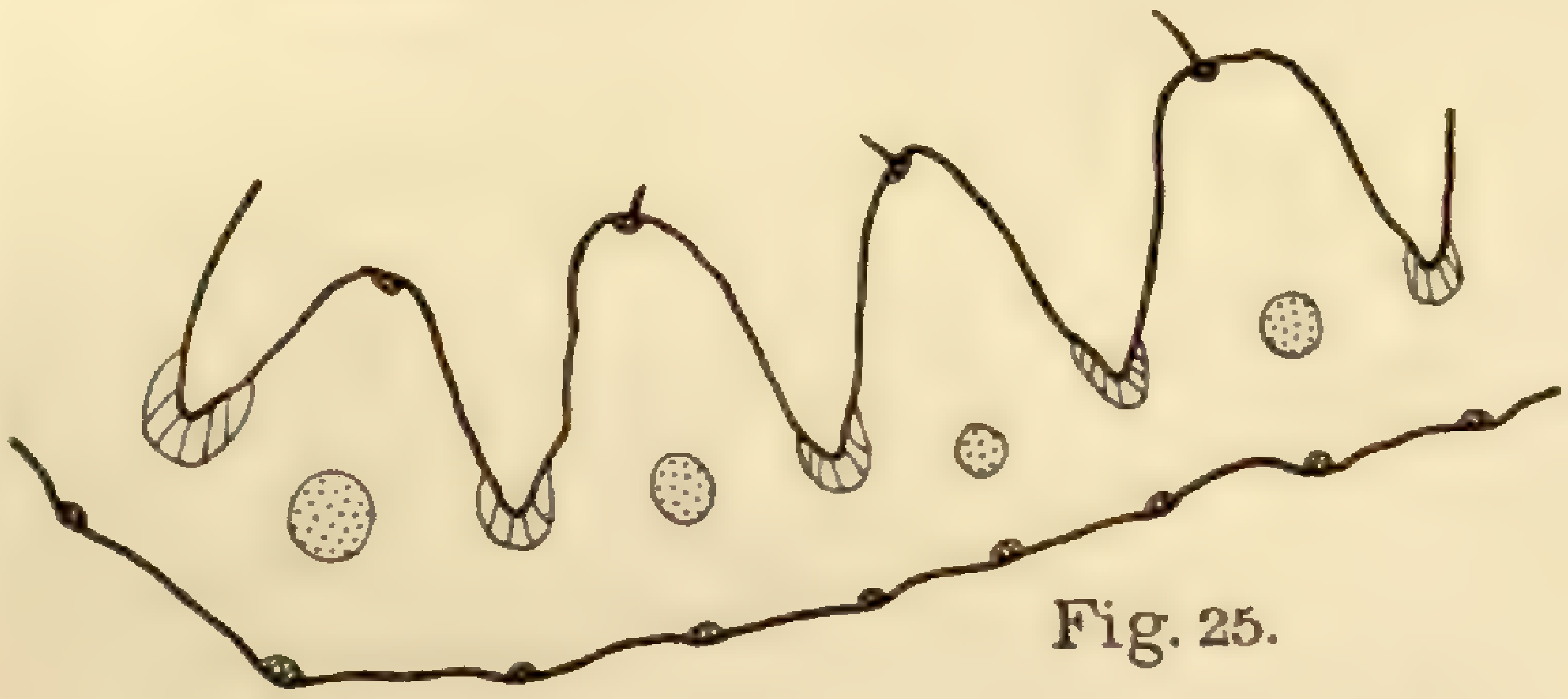

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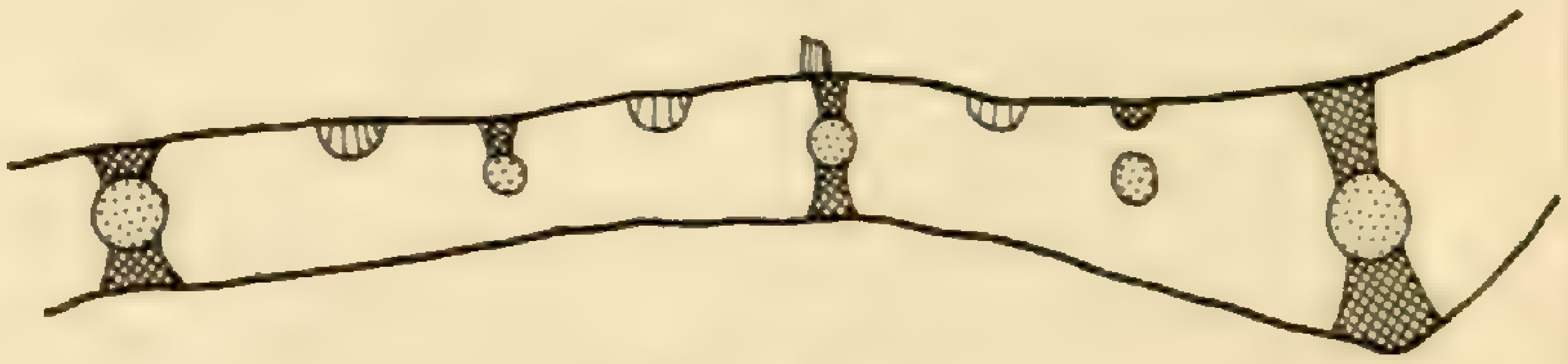

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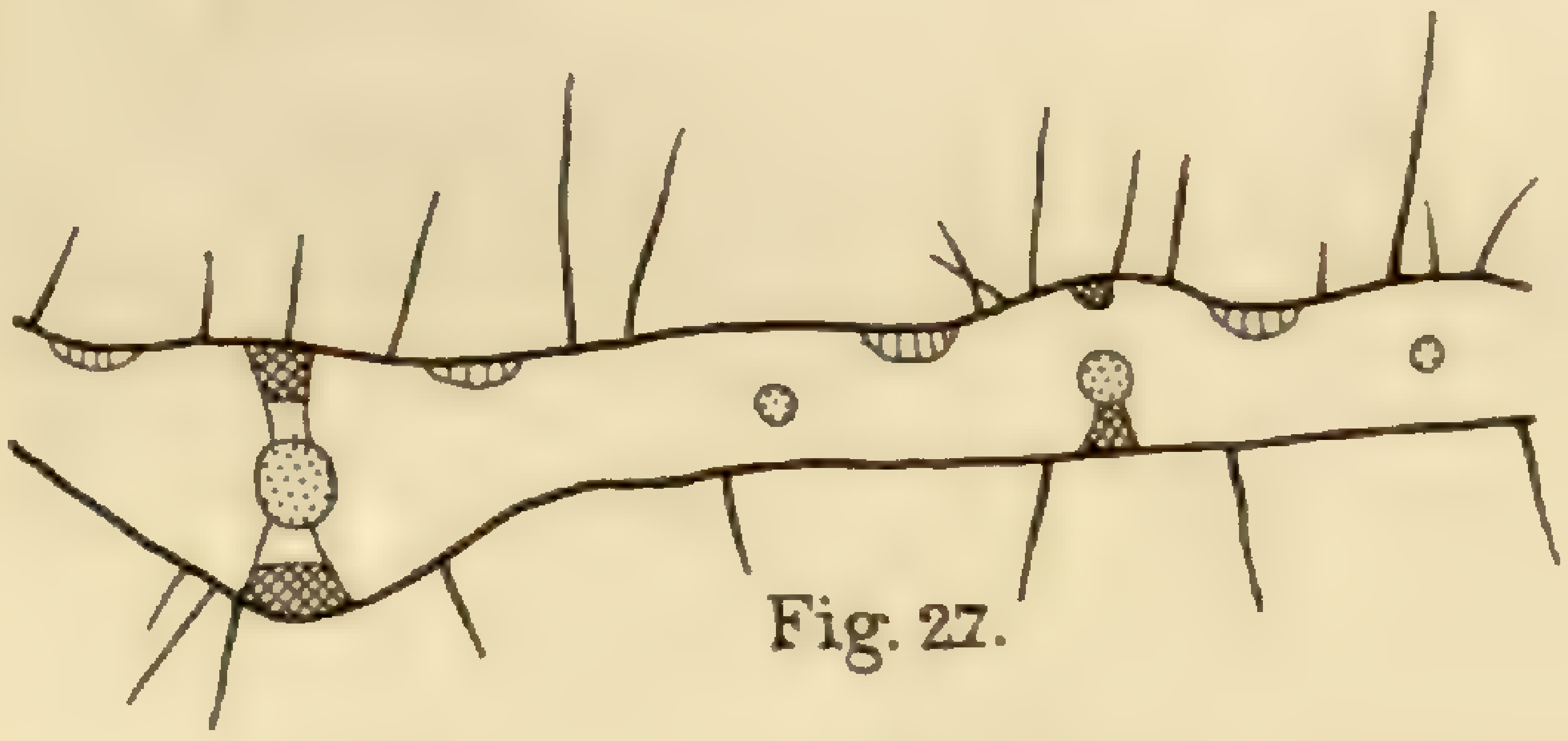

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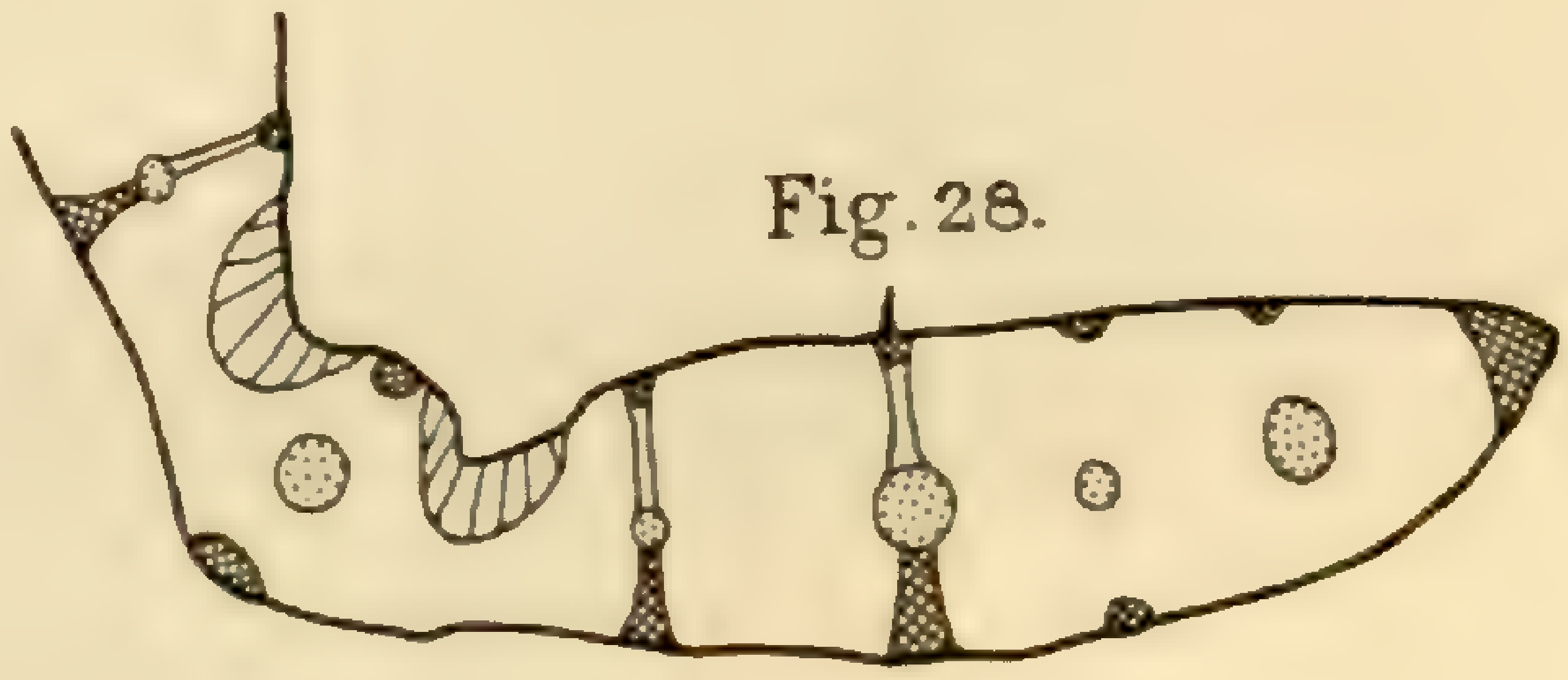
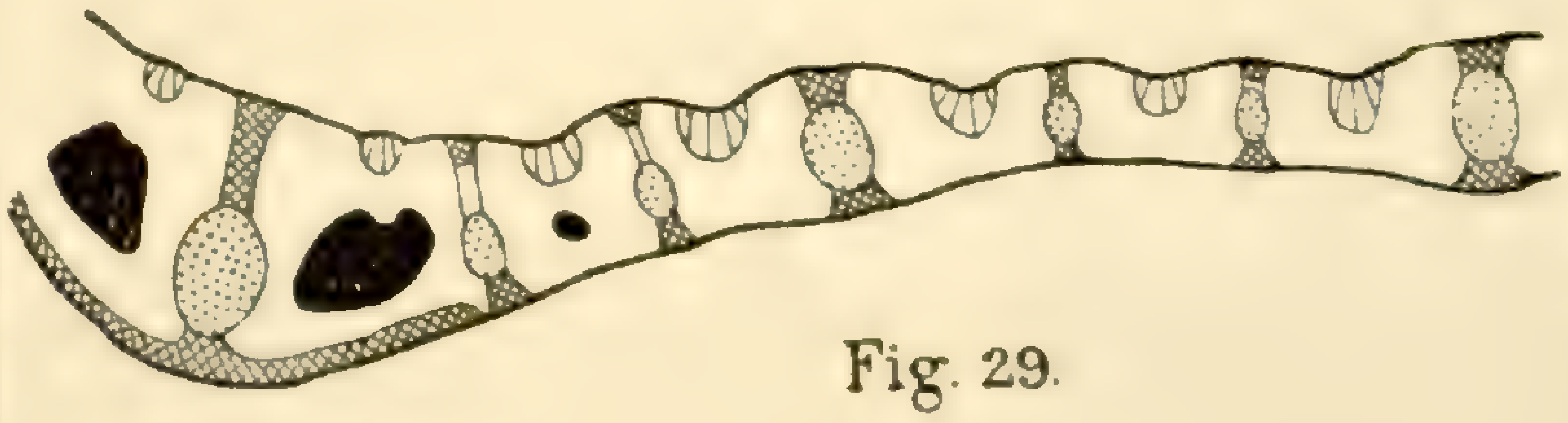


Fig. 28.

Lewton-Brain, del.

Collings, photosc.

LEAVES OF BRITISH GRASSES.



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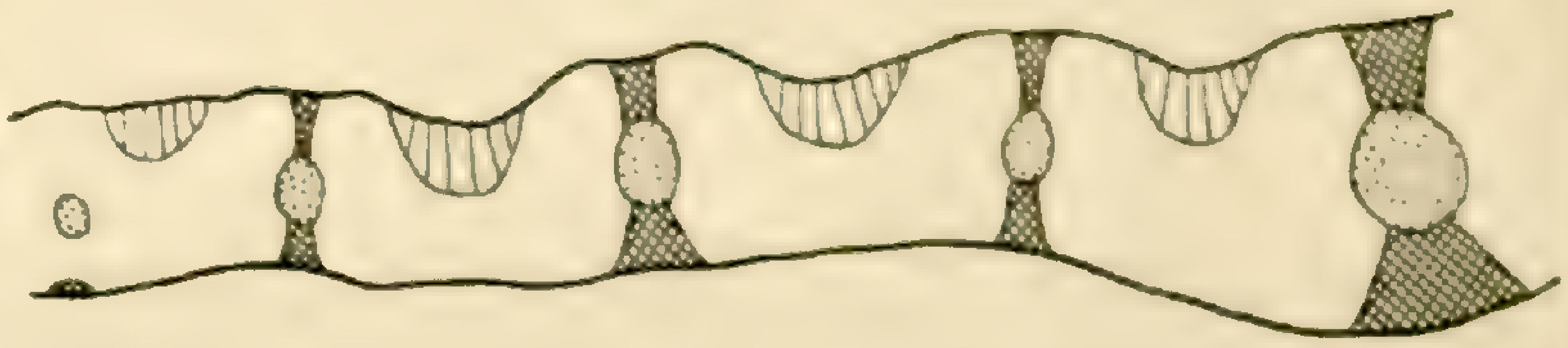

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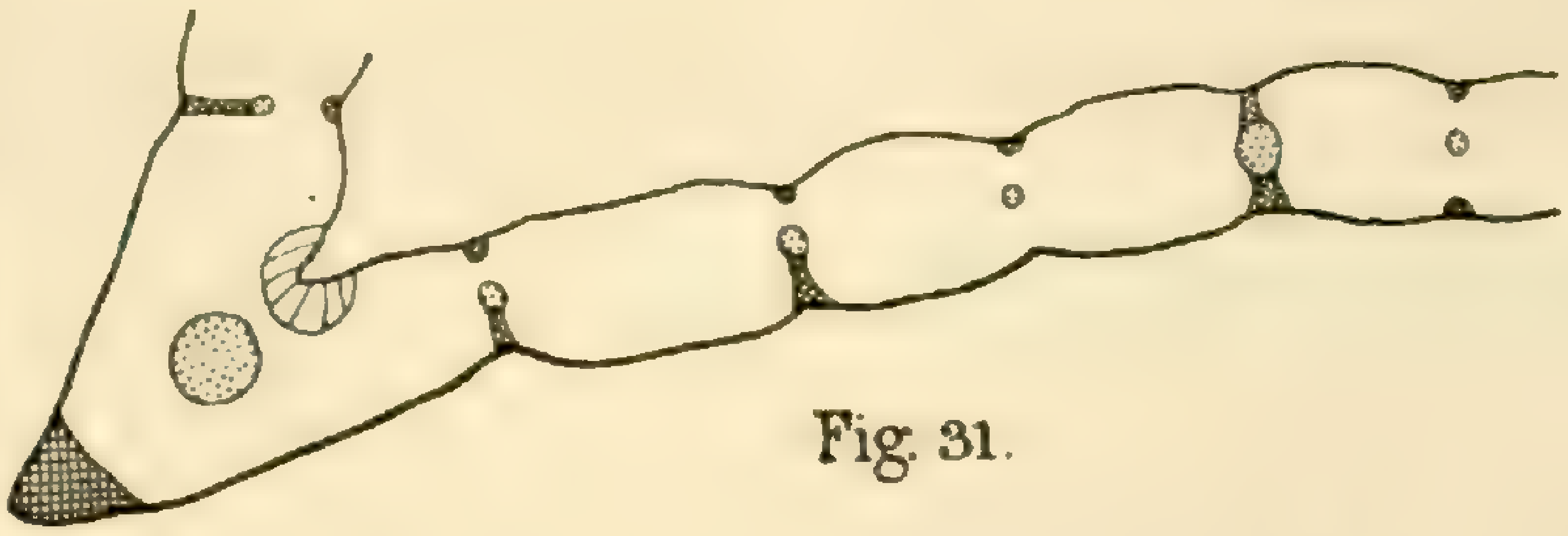

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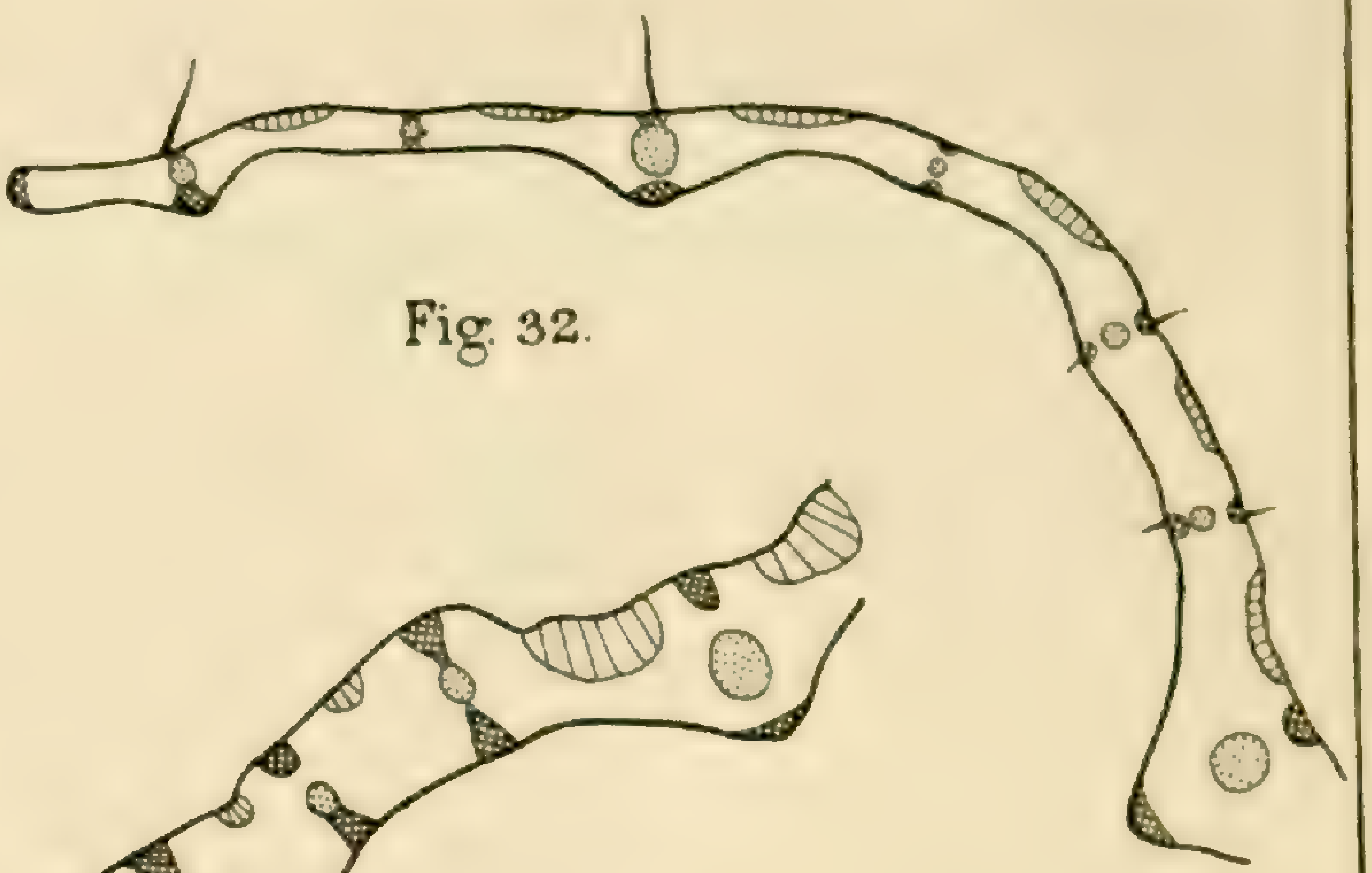

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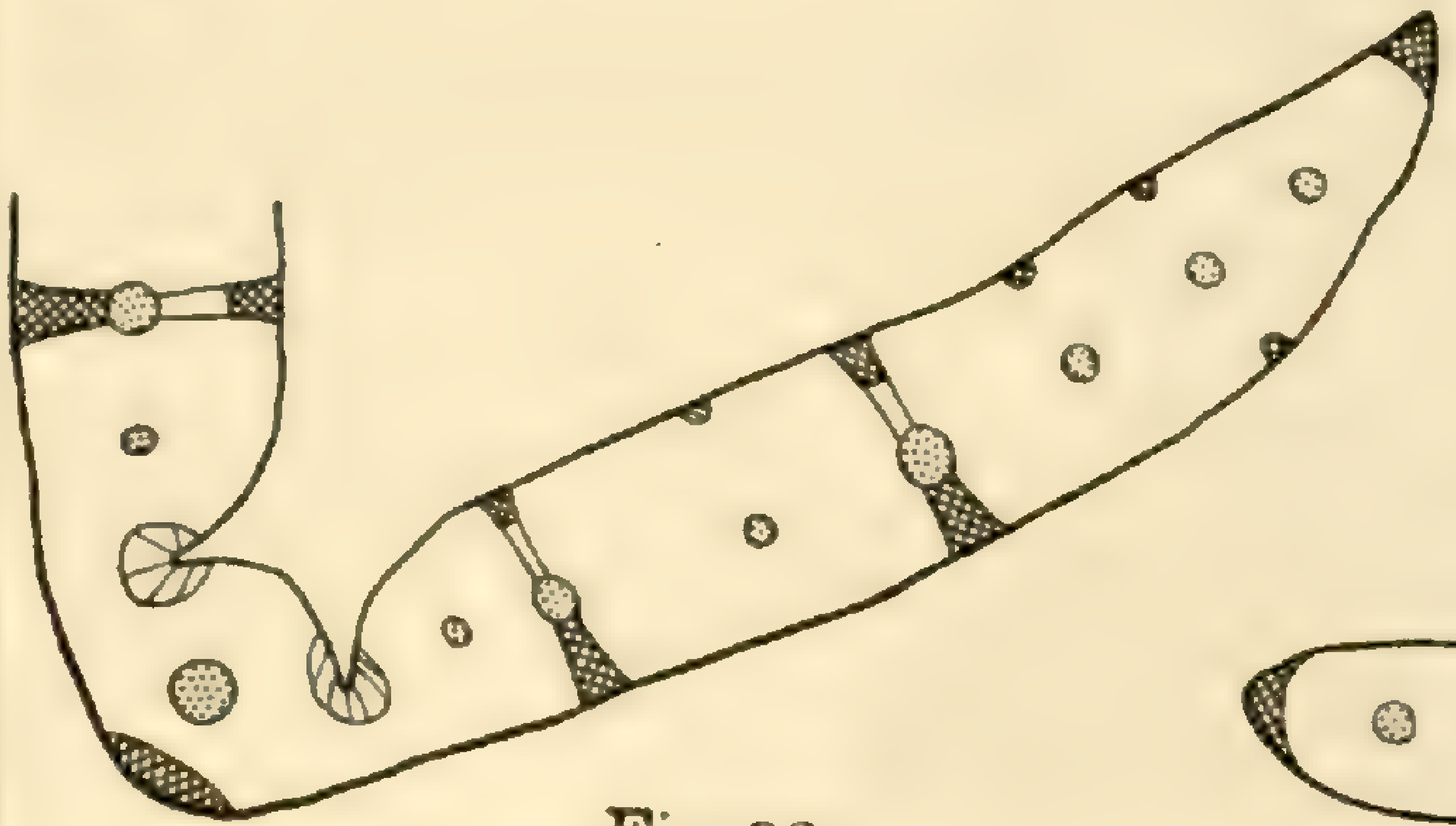

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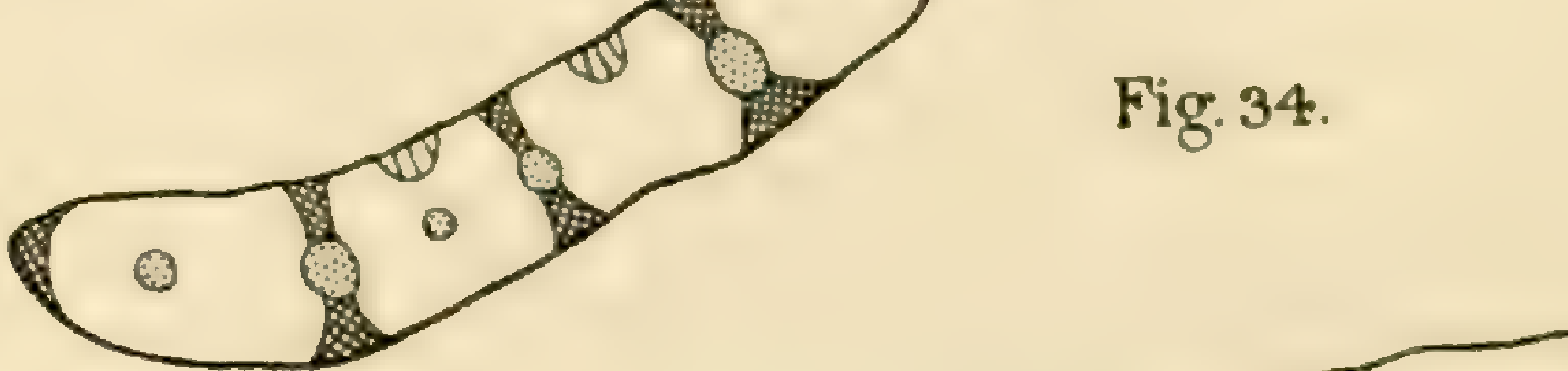

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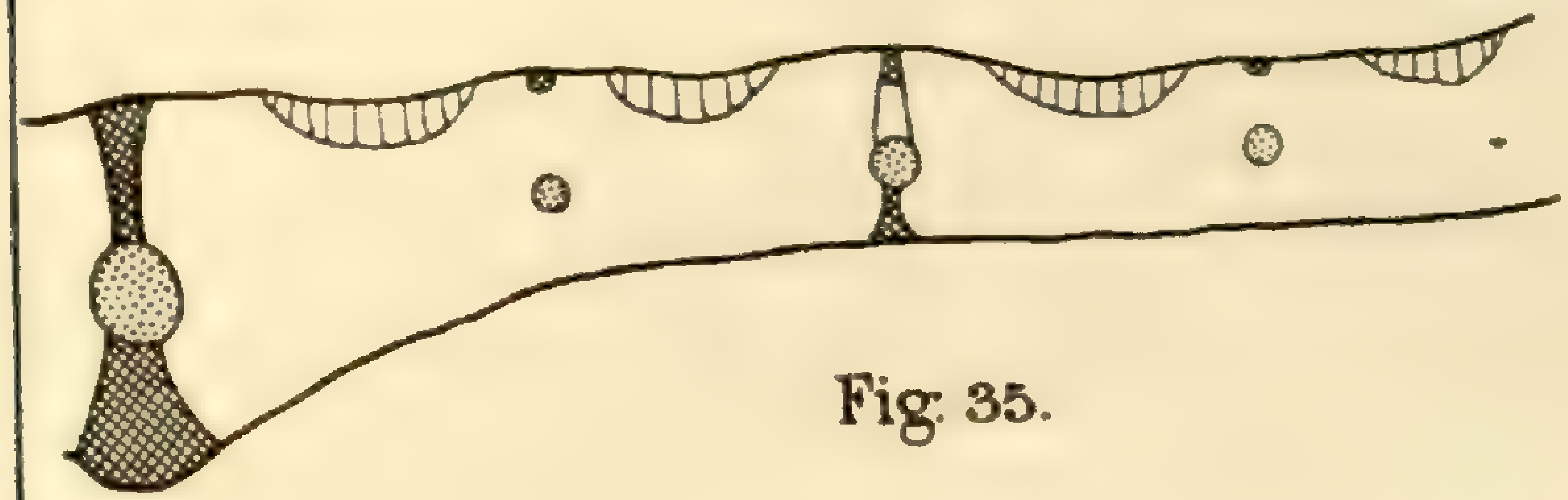

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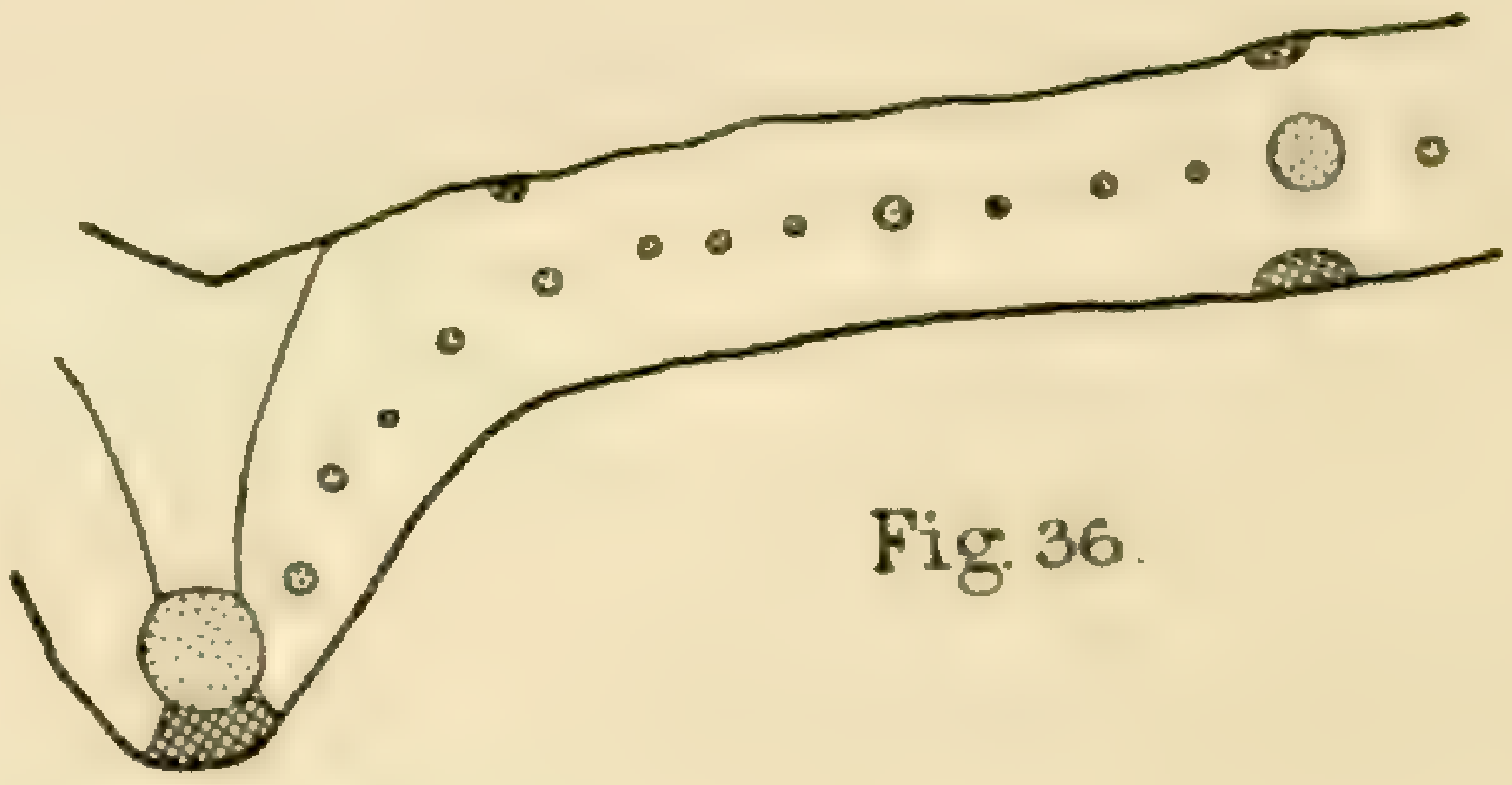

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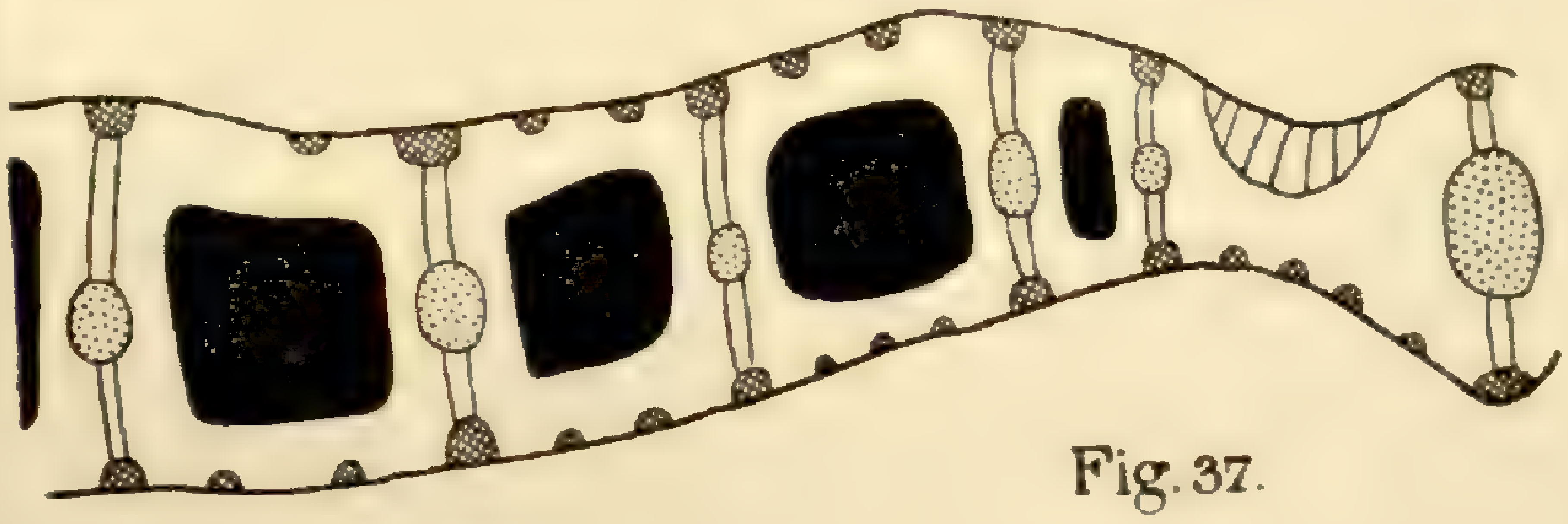

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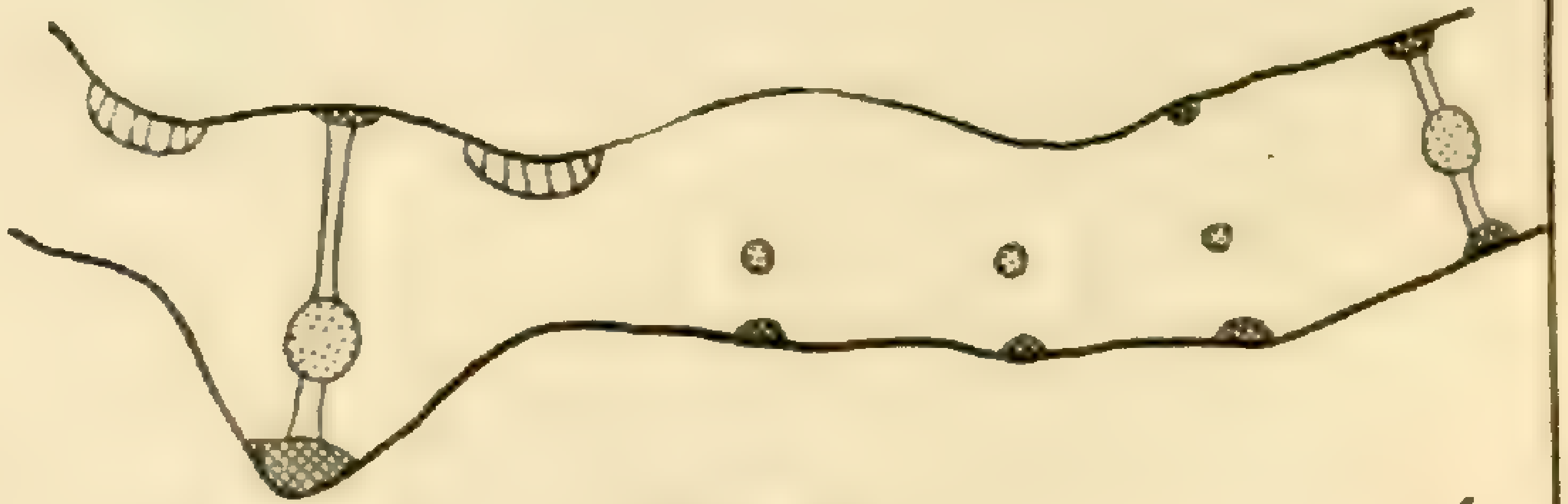

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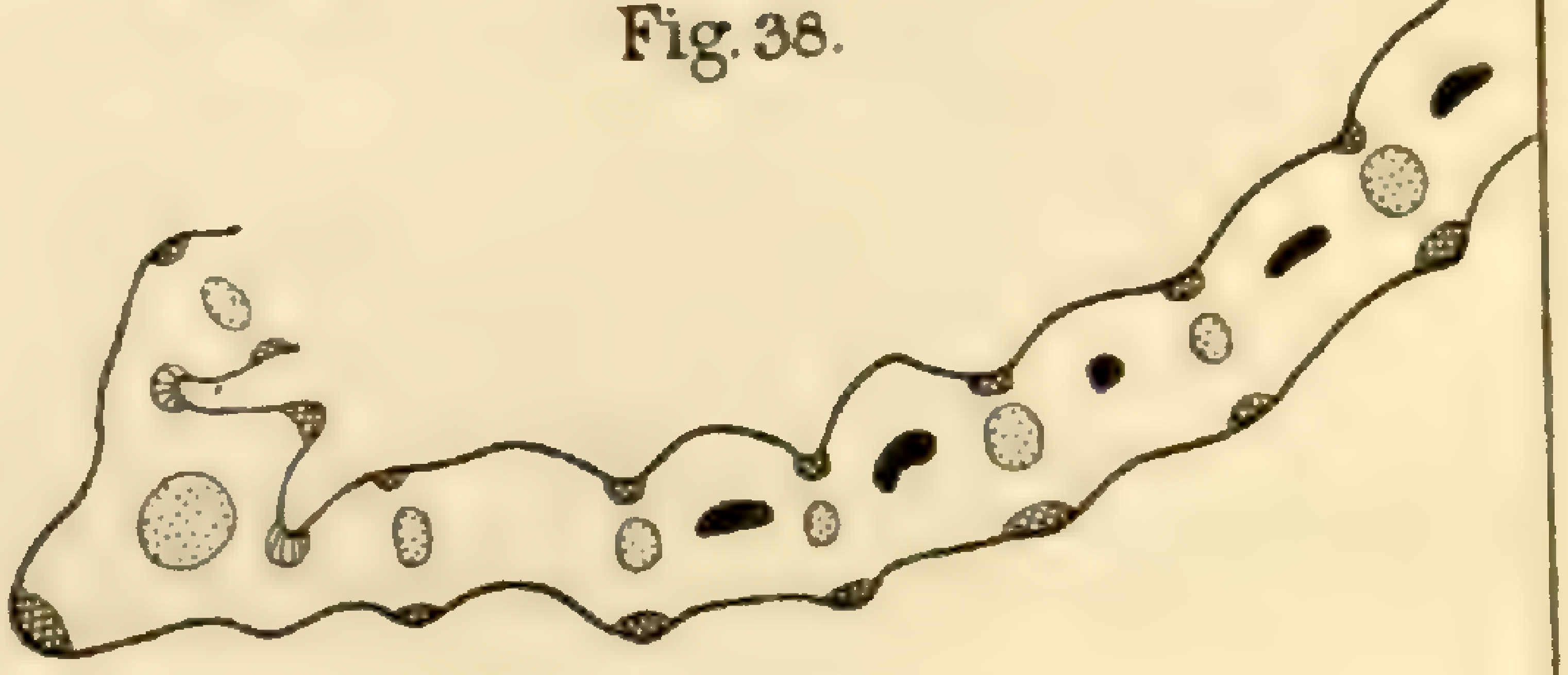

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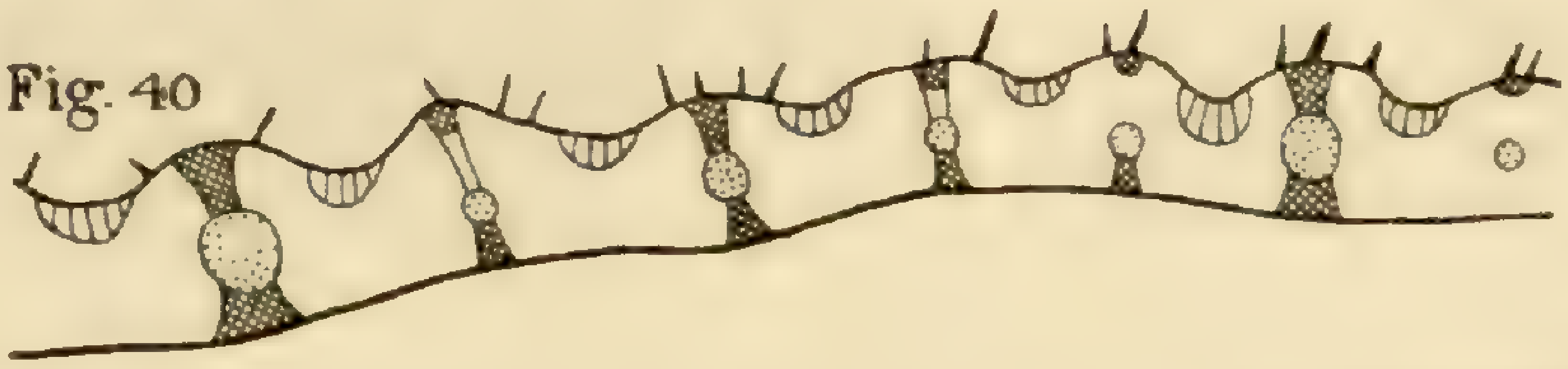
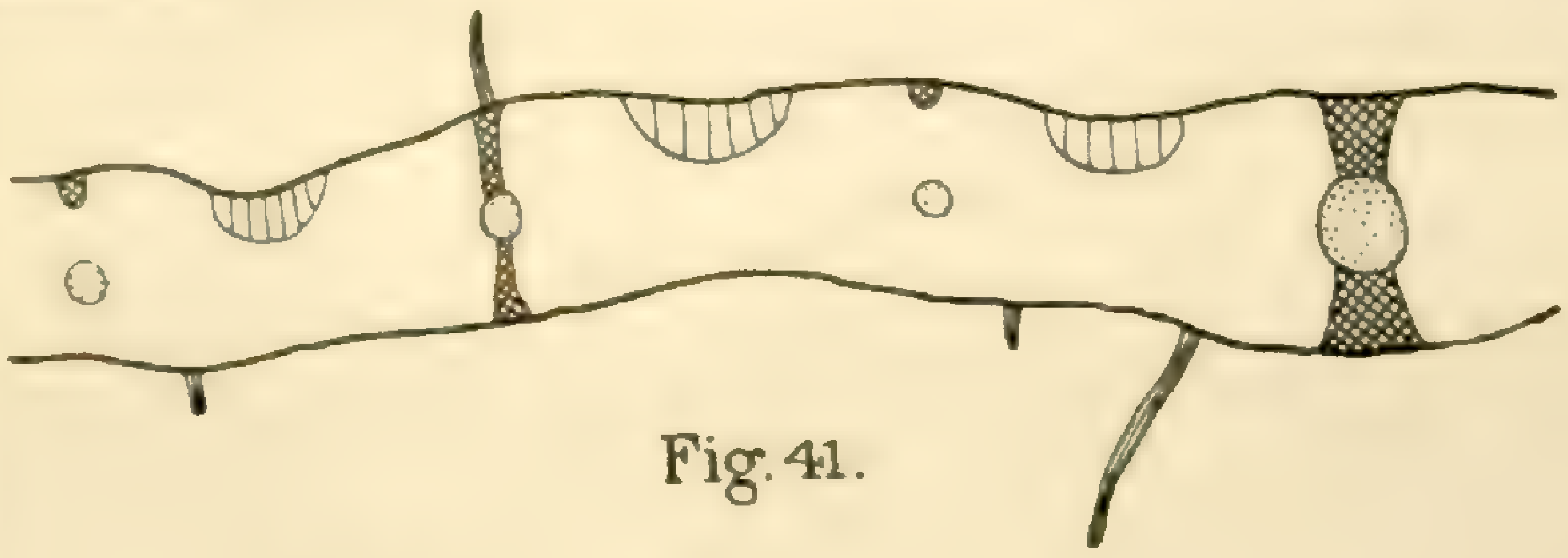
Fig. 40



Lewton-Brain, del.

Collings, photosc.

LEAVES OF BRITISH GRASSES.



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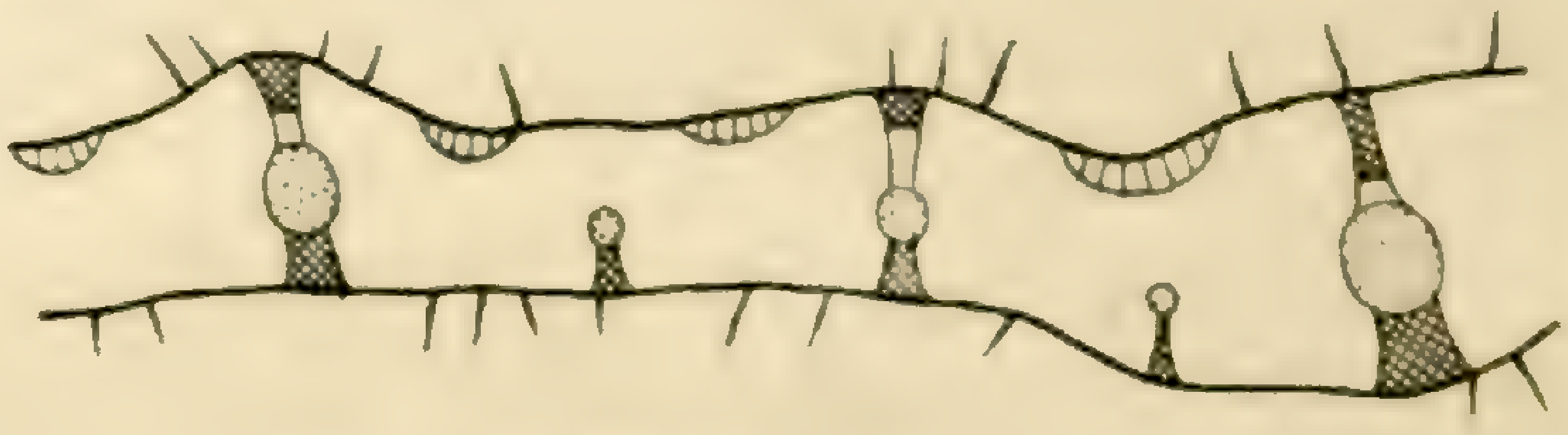

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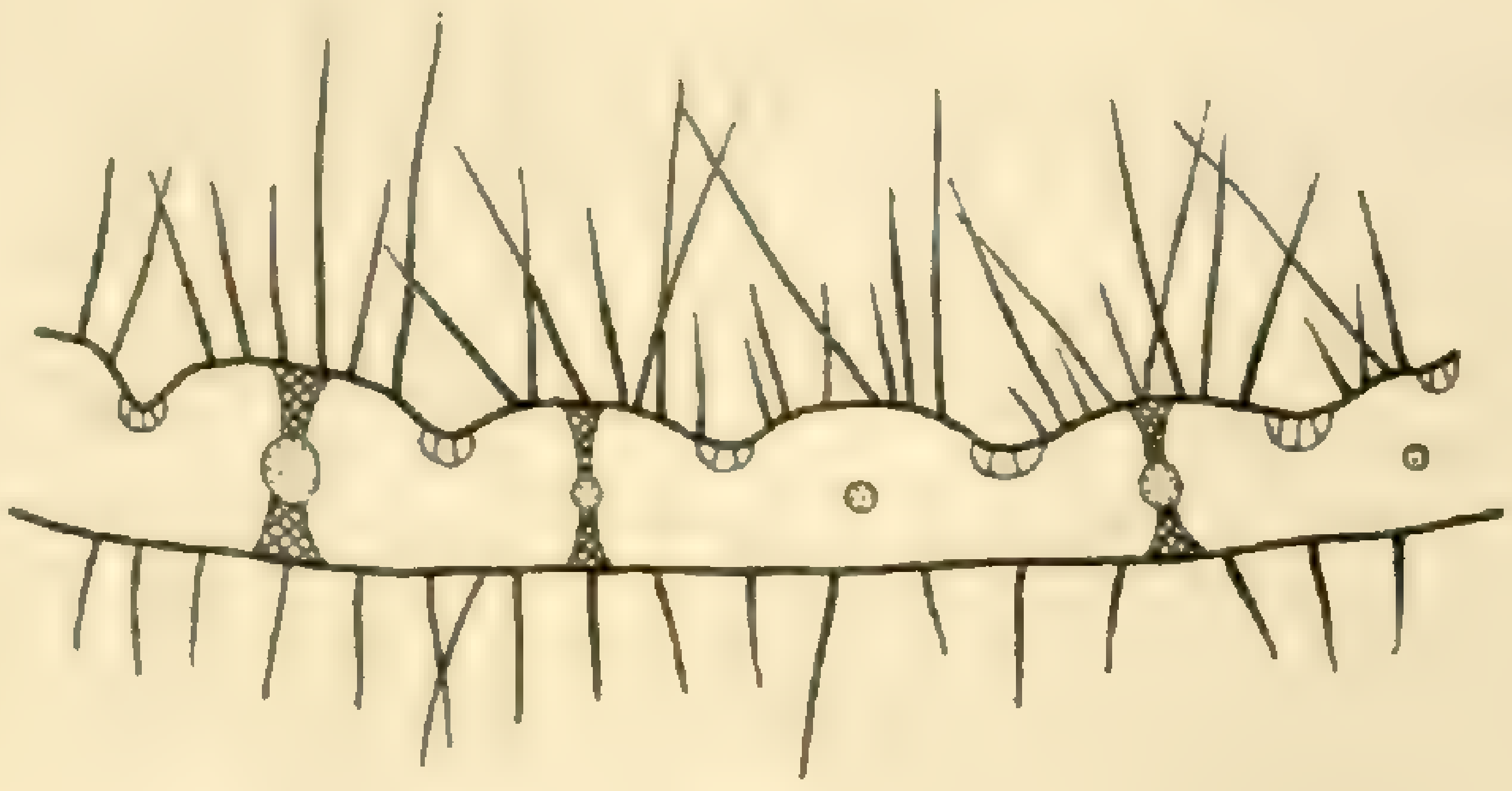

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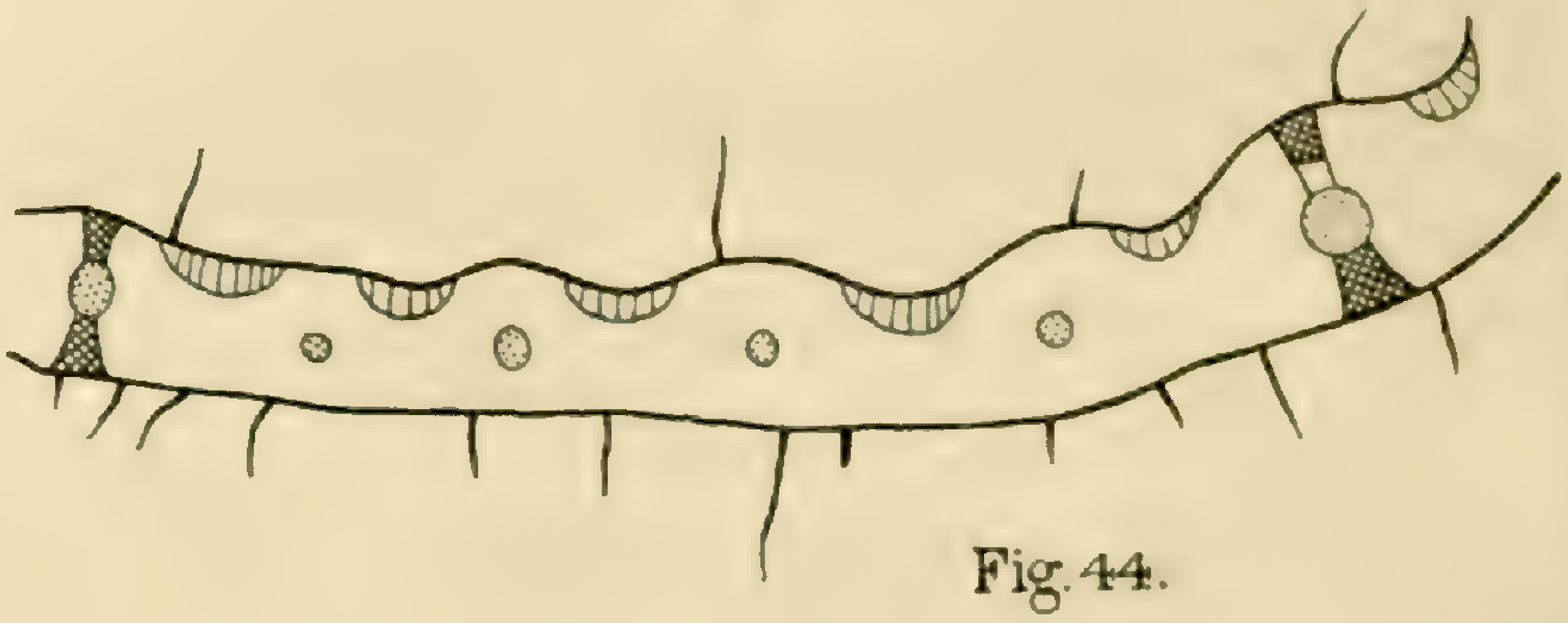

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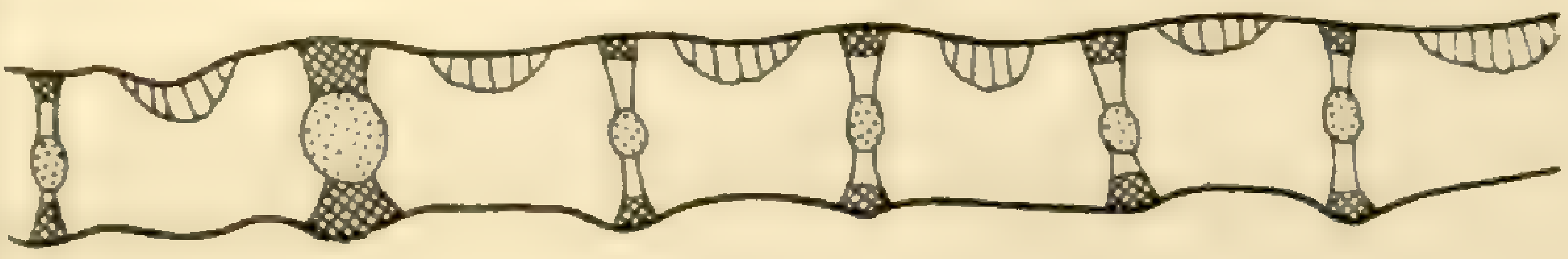

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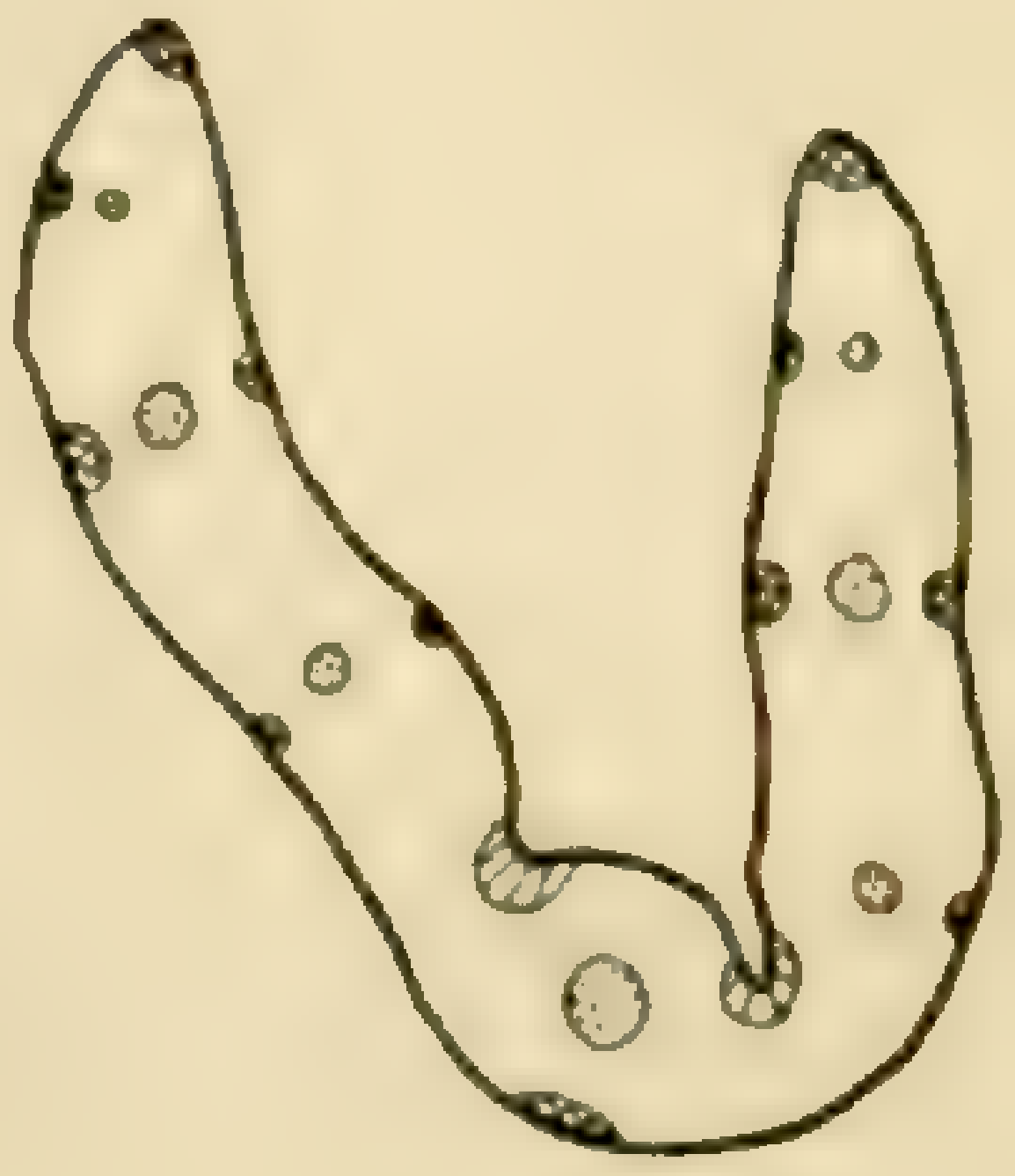

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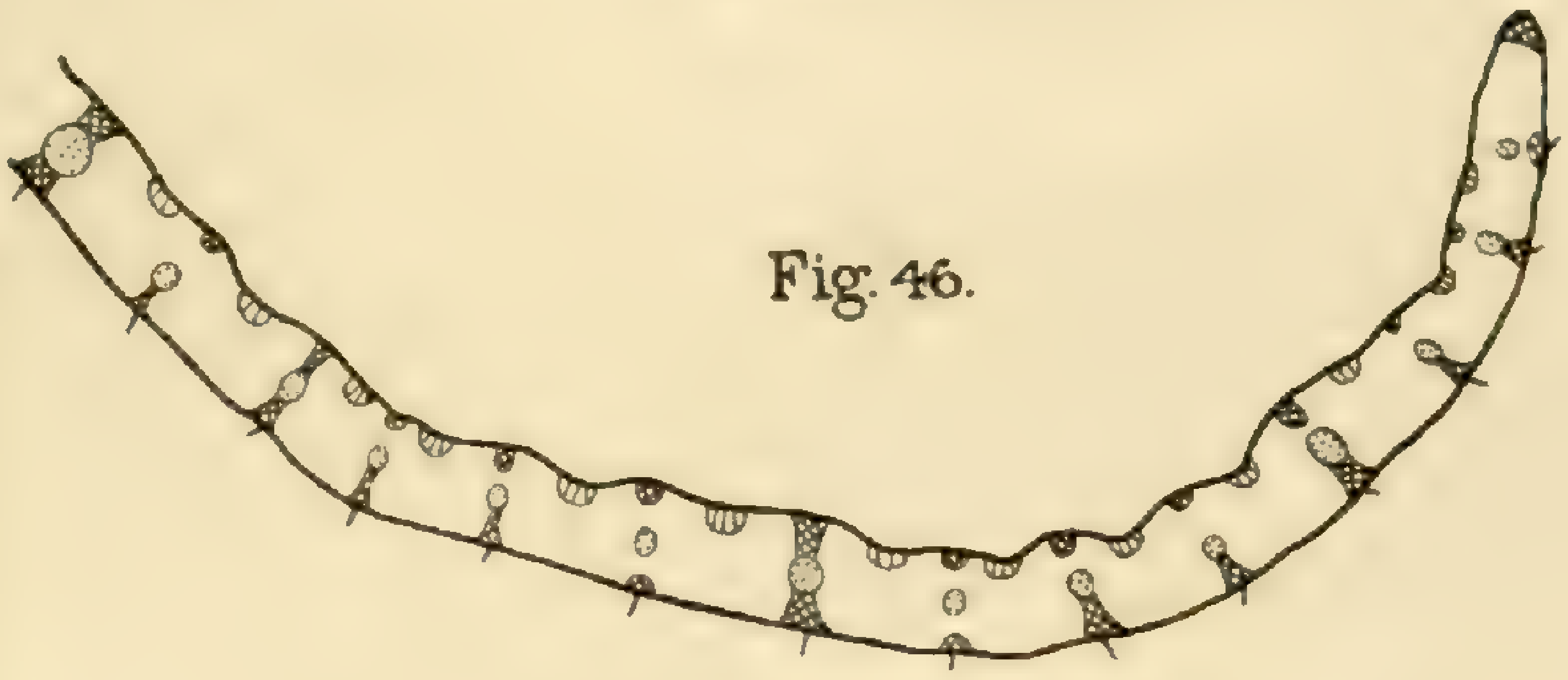

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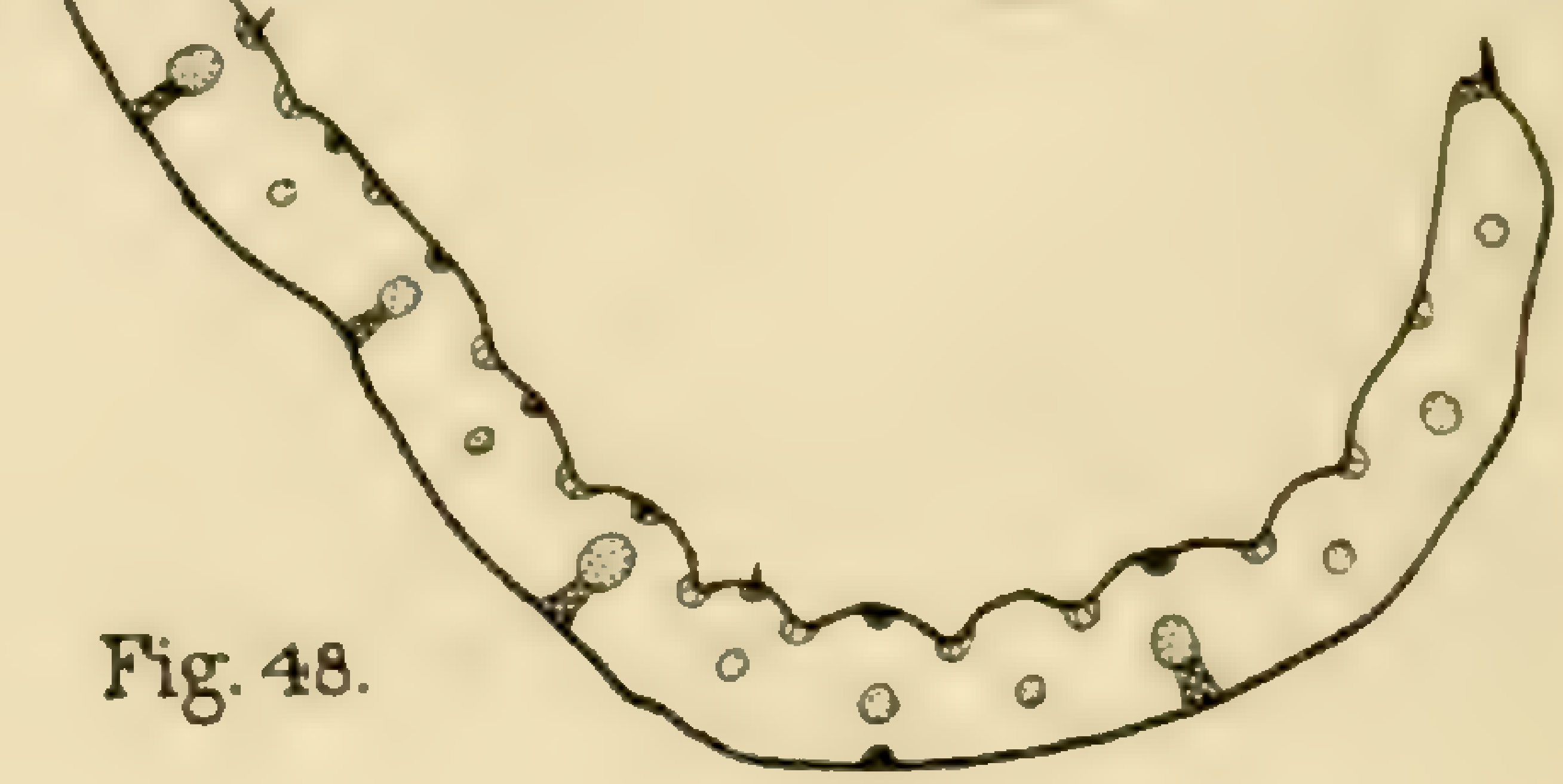

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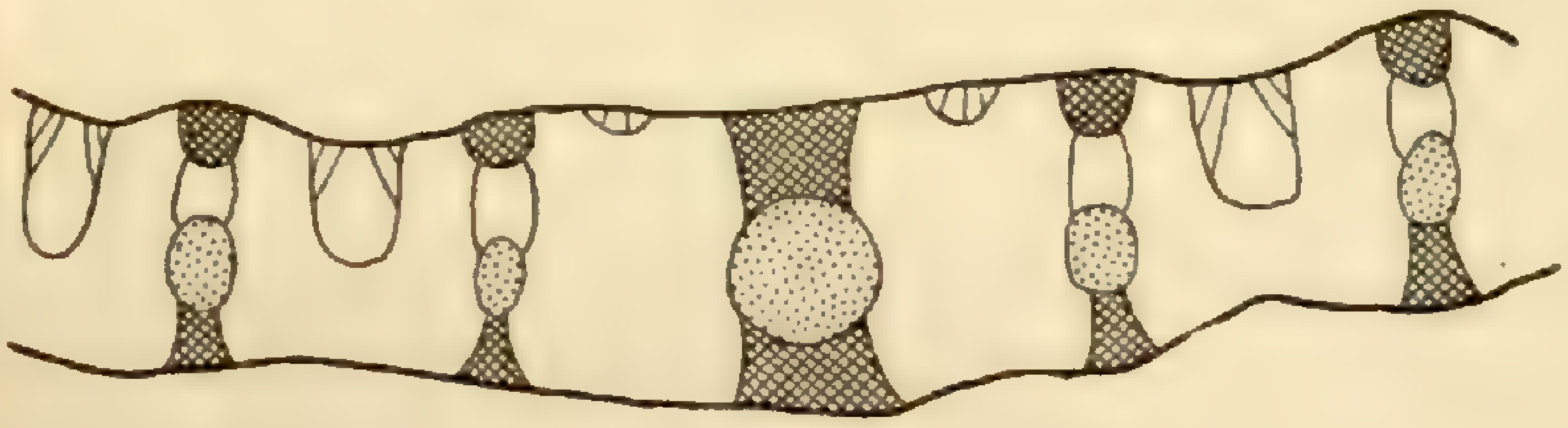

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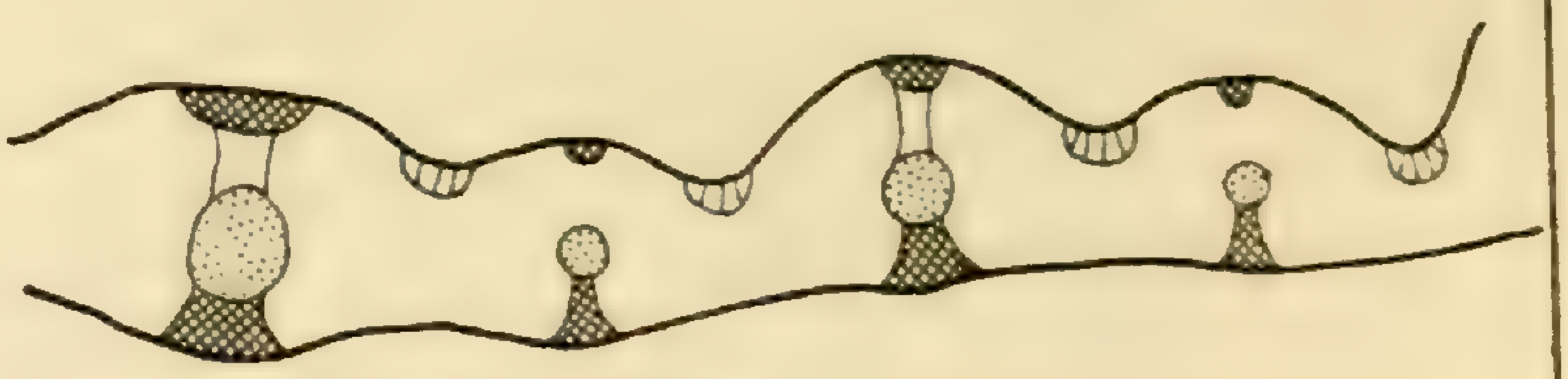

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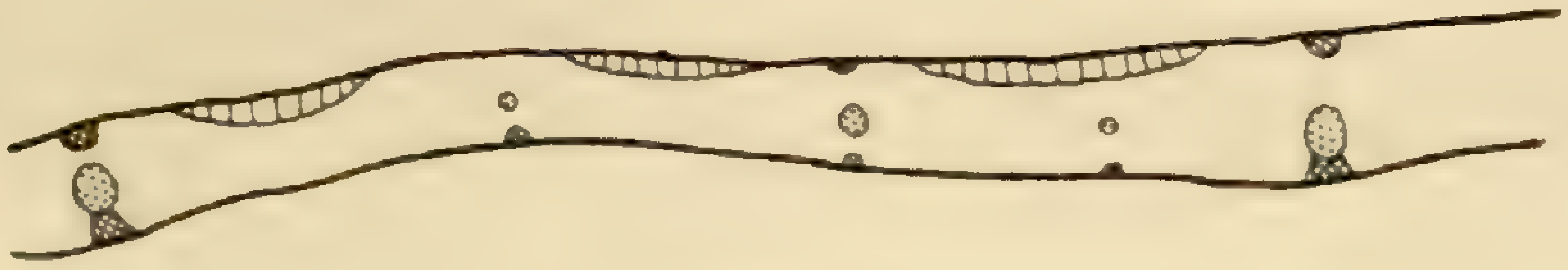

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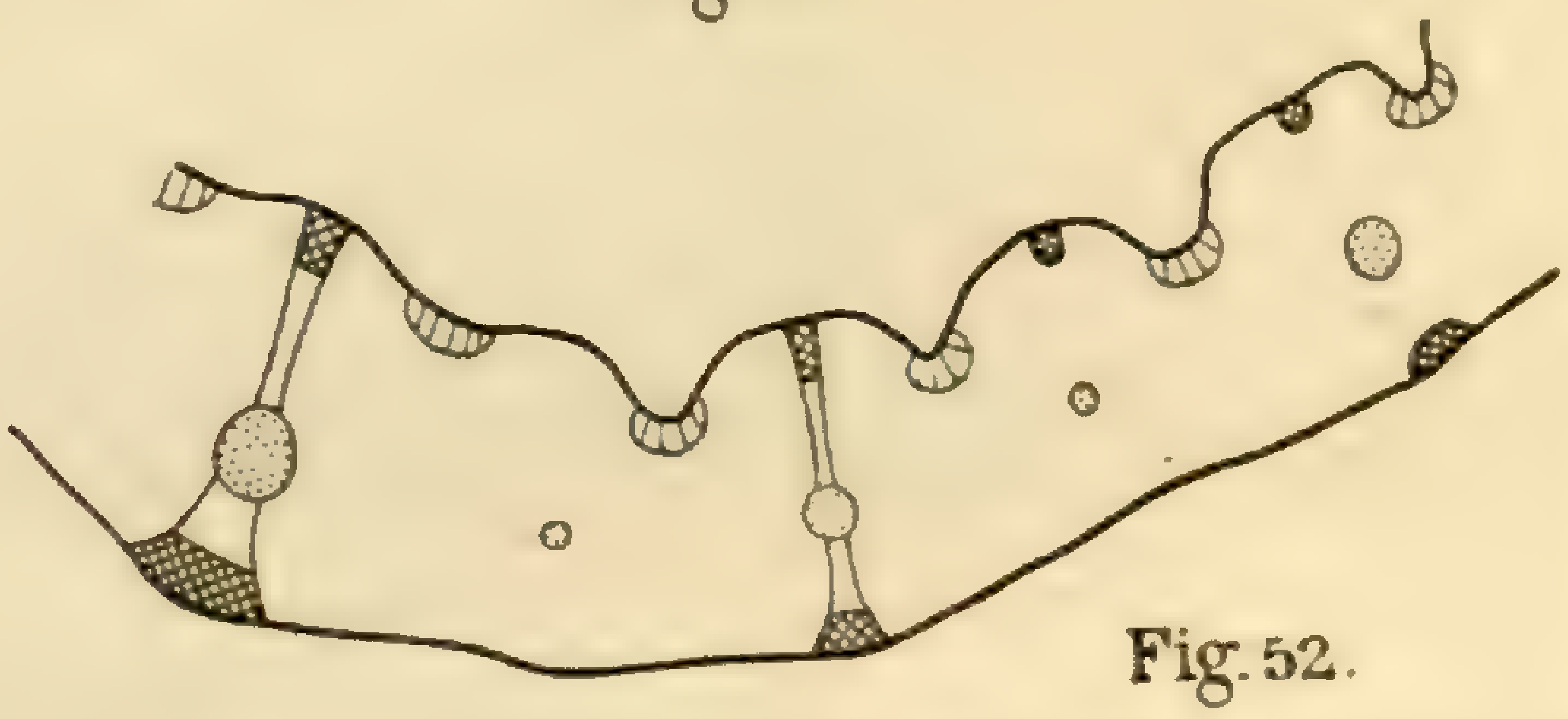

Fig. 52.

Collings, photosc.

Lewton-Brain, del.

LEAVES OF BRITISH GRASSES.

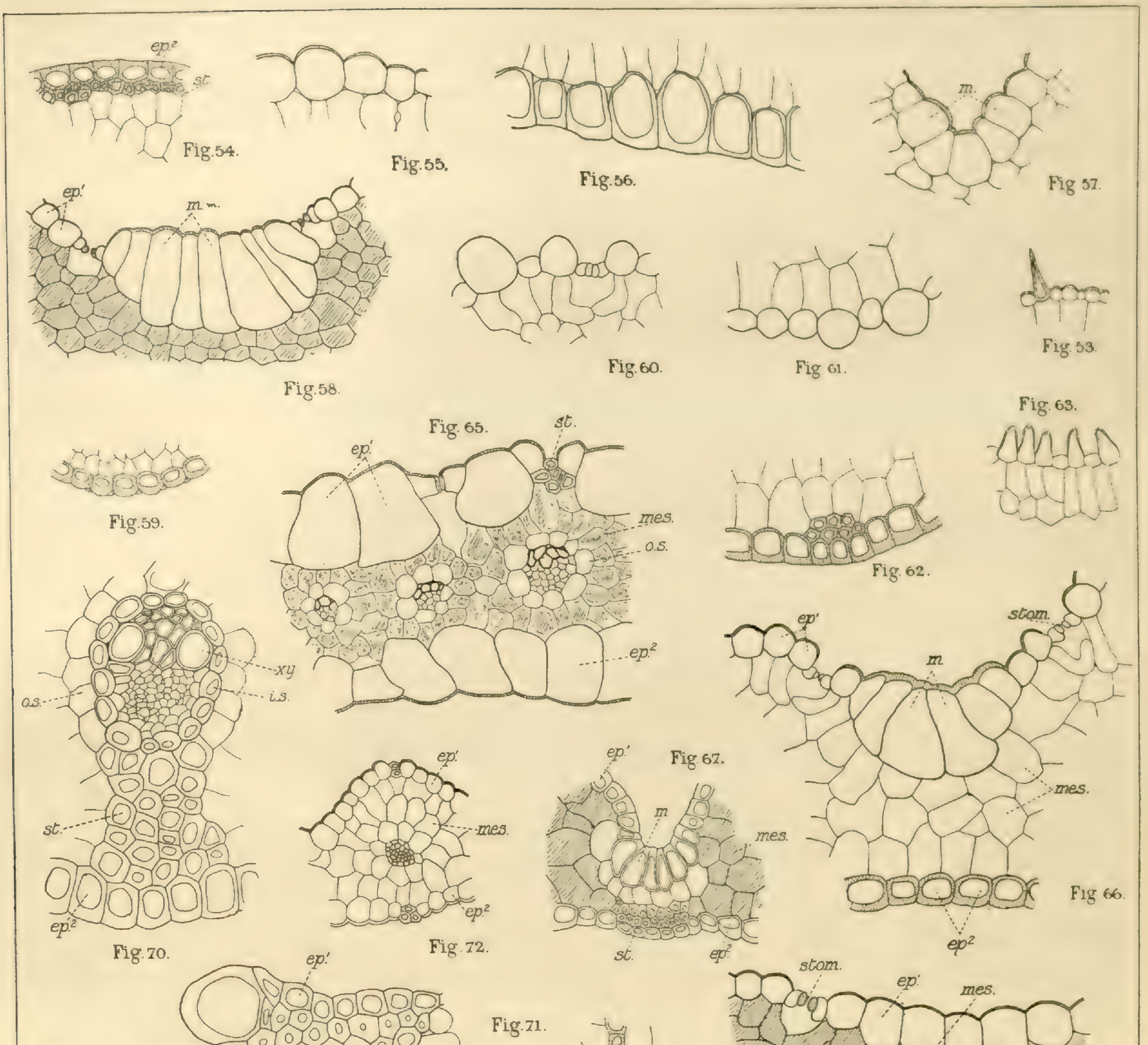
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Fig.54.
Fig.55.
Fig.56.
m.
Fig 57.
ep'
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Fig.60.
Fig 61.
Fig. 53.
Fig.59.
Fig. 65.
ep'
st.
mes.
o.s.
ep²
Fig. 63.
Fig. 62.
xy
o.s.
i.s.
st.
ep²
Fig.70.
ep'
mes.
ep²
Fig 72.
ep'
Fig 67.
m
mes.
st.
ep²
ep'
stom.
m
mes.
Fig 66.
ep²
Fig. 64.
ep'
st.
ep'
st.
ep²
Fig.68.
Fig.71.
i.s.
ep²
st.
stom.
ep'
mes.
Fig 73.
ep²
i.s.
xy.
Fig.69.
st.
ep'
p'
p²
ep²
Fig. 74.
m.
p'
p²
ep²
Fig. 75.

Lewton-Brain, del.

Collings, photosc.

ANATOMY OF LEAVES OF BRITISH GRASSES.

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	Part	XI. 1886.	0	6	0	0	4	6
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	Part	VI. 1903.	0	12	0	0	9	0
	Part	VII. 1904.	0	12	0	0	9	0

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THE TRANSACTIONS OF THE LINNEAN SOCIETY OF LONDON.

ON THE STRUCTURE AND AFFINITIES OF STEPHANOSPERMUM, BRONGNIART, A GENUS OF FOSSIL GYMNOSPERM SEEDS.

BY

F. W. OLIVER, M.A., D.Sc., F.L.S.,

QUAIN PROFESSOR OF BOTANY, UNIVERSITY COLLEGE, LONDON.

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VIII. *On the Structure and Affinities of* Stephanospermum, *Brongniart, a Genus of Fossil Gymnosperm Seeds. By* F. W. Oliver, *M.A., D.Sc., F.L.S., Quain Professor of Botany, University College, London.*

(Plates **41–44**.)

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Introduction.

THE last of many notable contributions to Fossil Botany by Adolphe Brongniart was a general account of the morphology of a large series of silicified seeds from the pebbles of Grand' Croix, near St. Etienne. Originally published in 1874[*], this contribution was re-issued in 1881 with numerous beautiful plates some years after his death as a memorial volume[†]. Of seeds having what may be termed a Cycadean organisation, Brongniart enumerates seventeen genera, a number which has been increased since. In the years that have elapsed since Brongniart's time many of these forms have been elaborated in greater detail by his followers, especially Renault, and in rare instances it has been possible to produce adequate evidence for referring a certain number to the plants to which they belonged. To this day the great bulk of the French seeds found in the later Palæozoic rocks, as also the less numerous forms from the English Coal-Measures, are known as detached structures, and their real affinity is a matter of conjecture. Notwithstanding this limitation, that we know these seeds only as detached structures, so important a portion of the plant is the seed that a detailed knowledge of the organisation of fossil seeds cannot fail to be a useful adjunct in unravelling the intricate phylogenetic history of recent plants.

It was in connection with one of these fossils—*Stephanospermum*—that Brongniart re-discovered the pollen-chamber, a structure at that time not generally recognised in Gymnosperms *. This observation led to others upon recent Cycads, whilst some years later we have the suggestion of Renault that the simpler Gymnosperms possessed antherozoids †, a forecast amply justified by subsequent researches upon *Cycas*, *Ginkgo*, and other genera.

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[*] Ann. Sc. Nat., Bot. 5^{e} sér. t. xx. (1874) pp. 234–265, pls. 21–23.

[†] 'Recherches sur les Graines fossiles silicifiées,' 1881.

Perhaps no group of plants has ever travelled so rapidly to the forefront of botanical interest as have the Cycads. On the one hand, we have the great discovery of 1896 of the fact of their zoidiogamy, bringing the Gymnosperms into the closest relations with Pteridophytes. On the other, along the independent line of vegetative anatomy, Scott, co-operating in and continuing the investigations of Williamson into our Palæozoic fossil plants, has, through the Cycadofilices, shown the great probability of the Filicineous ancestry of the Cycads ‡. This progress in our knowledge of the Cycads themselves, as well as of the fossil fern-like forms which reach up to them, renders a re-examination of the fossil seeds a pressing necessity. Though the general organisation of these seeds has been made known, there remains much in which uncertainty prevails. In particular may be cited the precise relation of the nucellus to its integument, the details of nucellar structure, the fate of the pollen in the pollen-chamber, and so on. There is, of course, the chance—a remote one, seemingly—that some lucky section may reveal evidence justifying the reference of a seed to the plant to which it belonged.

Owing to the courtesy of Monsieur A. Roche, the Palæontologist of Autun, it has been possible for me to commence the investigation outlined above. M. Roche has with great liberality put at my disposition a considerable number of uncut pebbles from Grand' Croix as well as Autun. These, together with others which I have collected in both localities, form the basis of the present communication. Towards the cost of preparing microscopical sections of these fossils I am indebted to the Royal Society's Government Grant Committee for a grant in aid.

The present communication is restricted to a consideration of two seeds from the Stephanian of Grand' Croix and to the bearing of the facts elicited. These seeds are *Stephanospermum akenioides*, Brongn., and an apparently new seed which it is proposed to name *Stephanospermum caryoides*. Brongniart, in his 'Graines fossiles,' divided the silicified seeds into two groups:—(1) Those exhibiting bilateral symmetry, more or less flattened, and probably of Cordaitean affinity; (2) Forms with radial symmetry and sometimes provided with longitudinal ridges, wings, &c. It is to the latter group that these seeds belong.

In selecting *Stephanospermum* for first treatment I have been influenced partly by the fact that it was fairly abundant in the material at my disposal, but more particularly by the relative perfection of its preservation and the rather unusual characters of its organisation. In any case, a re-examination of *Stephanospermum* is appropriate on several grounds, whilst with the facts gained it may be possible to institute comparisons with other fossil seeds as well as with those of recent Gymnosperms. Taking first the general structure of *S. akenioides*, I shall proceed to a more detailed account of certain of its parts, and then, after describing the supposed new species, it will be possible to enter upon a more general discussion.

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* The pollen-chamber with pollen in it appears to have been first figured by Griffith in 1854 (Ic. Pl. As. tab. 378); see also Miquel, Journ. of Bot. vol. vii. 1869, p. 75. I am indebted to Sir William Thiselton-Dyer, K.C.M.G., for these references.

† 'Flore fossile d'Autun et d'Épinac,' pt. 2, p. 277.

‡ 'Studies in Fossil Botany,' Lecture xiv.

STEPHANOSPERMUM AKENIOIDES, Brongn.

General Structure.

The seed is ellipsoidal in form, circular in transverse section, and, so far as could be ascertained, possesses perfect radial symmetry, saving only in respect of the archegonia, which appear to be developed in one plane only. The longitudinal section represented in Pl. **41.** figs. 1 A and B is quite typical. The whole structure is limited externally by a hard testa (*st.*), consisting largely of palisade-like stereides. This tegument, following the terminology of Brongniart, would be termed the endotesta, but, as there appears to be a layer internal to it, that term seems inappropriate. I shall speak of it as the sclerotesta, reserving the term endotesta for the more internally-placed soft layer. At the base of the seed the sclerotesta is relatively thick, and bears in median sections of good specimens a small papilla symmetrically placed upon its external surface (see Pl. **41.** fig. 1 B, *pa.*). This is, no doubt, the point of attachment of the seed to the structure which bore it. At the papilla entered a delicate vascular bundle (*v.b.*) which, penetrating the testa, expands at the base of the nucellus into the basal tracheal plate (*t.d.*). From the horizontal part of the testa springs the nucellus, which appears to stand freely within the integument. Above the insertion of the nucellus the sclerotesta thins out to its normal dimensions. At the apex of the seed it tapers to a long sharp beak, which is perforated by a canal, the micropyle (Pl. **41.** fig. 1 A, *m.*). At the base of this beak the testa expands into a circular collar or *crown* with sharp edge directed forwards (*c.*). The top of the seed, between beak and crown, is occupied by a circular perimicropylar trough.

Extreme length of seed from base to apex of beak 10 mm. Transverse diameter of seed at mid-height 4–4·5 mm.

Within the testa we recognise the nucellus standing erect and apparently free within it. Towards the apex the nucellus tapers and seems to end in a beak or canal which engages with the micropyle. Between the nucellus and the testa a space is present, broadest around the upper fifth of the nucellus. The apex of the nucellus (the upper $\frac{1}{5}$–$\frac{1}{4}$) is the pollen-chamber (*p.c.*). It is cut off by a conspicuous transverse membrane from its main body, which was almost entirely filled with a prothallium. The whole nucellus is limited externally by an epidermis usually characterised by the carbonised contents of its cells (*ne.*). Of the tissue composing the nucellus little remains in the prothallial region. The macrospore by its enlargement has invaded and compressed the nucellar wall to such an extent that with one exception little is recognisable beyond the epidermis and a few flattened layers. The exception, and it is a notable one, is the tracheal mantle. The delicate bundle which enters at the chalazal end of the seed (Pl. **41.** fig. 1 B, *v.b.*) expands into a wide tracheal plate, the margin of which is on every hand produced as a thin and continuous mantle of spiral or scalariform tracheides. This mantle runs just below the epidermis of the nucellus, and reaches right up to the top of the macrospore. Here the tracheides pass into the lower region or extension of the pollen-chamber, paving its floor and lining its sides, but never penetrating to the upper portion or pollen-chamber proper. In the region of the pollen-chamber the lateral tissue of the nucellus is often preserved, forming an **S**-shaped pad of thin-walled, spindle-shaped cells right and left of the obtuse tapering apex (as seen in a median longitudinal section, *e.g.* in fig. 2, *sh.*). This tissue, however, dies out before the canal connecting the pollen-chamber and micropyle is reached.

At the junction of the nucellus and the narrow canal just mentioned there occurs almost invariably what at first sight appears to be a sort of collar folded down over the top of the nucellus like a small inverted funnel (Pl. **41.** figs. 3 & 1 A, *co.*). The structure is very puzzling in all sections not ground to their ultimate fineness. It forms a characteristic feature in the Brongniartian drawings * like a pair of backwardly-directed antennæ, but no direct reference is made to it in the literature.

The macrospore is limited by a well-defined and fairly thick membrane in contact laterally with the attenuated residue of the nucellus; but at the apex always, and at the base frequently, it has undergone considerable contraction, so that in these regions it no longer follows the contour of the nucellus. In the living seed the base of the macrospore, no doubt, fitted on to the chalazal tissues; whilst at the apex it was convex, encroaching considerably upon what is loosely termed the pollen-chamber.

As regards the contents of the macrospore I have nothing to add to what is shown in Brongniart's figures. A prothallium more or less contracted from the wall is usually preserved (Pl. **41.** fig. 3, *pr.*), and in lucky sections archegonia are found below the pollen-chamber (fig. 3, *ar.*). These seem to have been present to the number of two; and if this be really the case, the gametophyte alone in this seed exhibits bilateral rather than radial symmetry. But I was unable to settle this point by a critical section, such horizontal sections as have been obtained through this region being ill-served as regards the preservation of the prothallium. Though the egg-cell, which was large, and what is perhaps its nucleus, often shows as a striking cytological object (Pl. **41.** fig. 3, *ar.*), no details of morphological value are recognisable.

Above is given in brief outline a general account of the more obvious features of the seed. I now pass on to speak in fuller detail of certain regions.

The Testa and the Chalaza.

Except at the chalaza and at the apex of the seed the sclerotesta has a uniform structure and thickness (·33 mm.). Externally there is a palisade-layer (Pl. **41.** fig. 4, *p.*), in height about half the diameter of the sclerotesta. This layer is supported by a zone of short thick cells, whilst below these are several layers of fibres (*f.*) which run in the longitudinal direction. As a lining to the sclerotesta we find a well-marked layer of fairly large flattened cells with carbonised contents and clear refringent walls (*et.*). This layer, which may be termed the epithelioid layer of the sclerotesta, becomes continuous at the chalaza with the epidermis of the nucellus, and agrees with it in its histological characters (Pl. 43. fig. 21, *et.* & *ne.*). All the layers of the sclerotesta appear thick-walled and sclerotic, and all but the lining layer have brown cell-walls. The walls and contents of the former are often excellently preserved. The protoplasm is contracted away from the wall except at certain points where finger-like processes remained, as in fig. 22, which shows the ends of two sclerotic cells from the third layer from the surface. Fig. 23 represents another cell from immediately below the palisade-layer. In almost all the cells the nucleus appears to be represented by a dense body usually surrounded by a light contour. In the palisade-layer the preserved contents take the form of a long and often slightly sinuous filament with a local enlargement where the nucleus is contained (fig. 24, *n.*, also fig. 21, *l.p.*). At the peripheral ends of these cells, with rare exceptions, and sometimes at their internal ends, the filament expands into a low, hollow, conical vesicle, the base of which is closely pressed against the limiting membrane (as at *v.*, fig. 24). More frequently we find at the internal ends paired finger-like processes (*p.*, fig. 24) which vividly recall pits. Occasionally, in the same position, there is a vesicle with a pair of short processes directed towards the cell corners. No doubt all these appearances were occasioned by the adhesion of the protoplasm to the wall, and it is difficult to resist the inference that a pitting of the end walls has been largely concerned in the production of the finger-like processes. But a detailed discussion of the matter would not be appropriate here. Palisade-cells are shown in transverse section in fig. 25. The apparent great thickness of the walls of the palisade and supporting cells of the sclerotesta is very probably exaggerated through preservation. The direction followed by the former is horizontal at the middle of the seed (where it is broadest); above this zone, and below, these cells gradually acquire an increasingly steep angle, till at the chalaza their course is parallel to the axis of the seed; whilst at the "crown" or perimicropylar ring they run up directly into this structure (*cf.* Pl. 41. figs. 1 A & B). The apex of the seed merits detailed description. The sharp ridge or crown which surrounds the micropylar beak is composed of an extension of the palisade-cells. The trough or moat which it contains is generally empty (figs. 1 A & B). Occasionally, however, the lining-surface of the trough bears a loose tangled feltwork of long filaments forming a brush inserted over the concave surface and reaching up to the micropyle (Pl. 41. figs. 2, 5, & Pl. 42. fig. 10). The component parts of the feltwork show little obvious indications of cellular structure. Two sorts of elements can be distinguished. First, there are indistinct remains of tubular cell-membranes much crumpled and distorted, and, mixed with these, filaments of extreme fineness, often following a sinuous course and occasionally expanding into small lenticular thickenings. Taken in conjunction with the normal type of preservation of the palisade-cells just described, the matted feltwork becomes intelligible. The membranes are the much-macerated walls, and the sinuous filaments the contracted contents of long cells or rows of cells. In some cases the membranous portion has been denuded away, and the tissue which once occupied the trough is represented by its protoplasmic contents alone. Of the original nature of this tissue it is difficult to judge. It may have consisted of tufts of real hairs, or of a spongy thin-walled palisade, or perhaps of a succulent cushion. On the whole a delicate tissue seems indicated, for the filaments are rarely preserved although they occupy the most secluded position that the whole surface affords. The projecting rim may have been continued to the lip of the micropyle as a thin shell overlying a spongy tissue such as we know to have existed in *Ætheotesta elliptica* *. If so, the lid must have been caducous, as no indications of disintegration or splintering are found on the sharp edge of the crown. In these circumstances our seed must have presented a very close resemblance to *Ætheotesta*.

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* 'Graines fossiles,' pl. 16. figs. 5, 8, &c.

In this connection it is interesting to recall the fact that Renault has conjectured, from analogy with *Gnetopsis* (another seed from the same horizon), that the crown of *Stephanospermum* was the base of attachment of a plumed organ concerned in the dispersal of the seed †.

Whatever may have been the function of this micropylar organ, the fact is not without interest that the micropyle of this seed was more complicated than had previously been shown. Apart from the apex of the seed, no certain trace of a soft tissue external to the shell has been found. But, as it sometimes happens that even the hard sclerotesta of this seed shows evidence of superficial wear, it would be rash to conclude that a sarcotesta had not existed. From analogy with *Ætheotesta* ‡, *Trigonocarpus* §, and *Polylophospermum* ‖, members of the *Stephanospermum*-group from the same horizon, the existence of such a layer is not wholly improbable.

As regards the lining of the integument, this layer of flattened cells with dark contents may be traced from the chalaza to the commencement of the micropylar canal. Here it seems to lose its characteristic appearance (*cf.* Pl. **43.** fig. 29, and Pl. **41.** fig. 4, *et.*), and is continued as an inconspicuous lining to the canal traceable with difficulty to the apex. That it was a sclerotic layer seems open to question.

The Chalaza ¶.—The base of the seed where nucellus and testa are confluent is not without interest. The sclerotesta in this region is much broader than elsewhere, due to the fact that the palisade-cells become about three times as deep here as elsewhere. At the centre, around the entering bundle with which these cells are parallel, they are undivided and have a length of ·8 mm. (see Pl. **43.** fig. 21, *lp.*), whilst further away from the bundle they are segmented into two or three storeys. Beyond, as we come level with the separation of sclerotesta and nucellus, the palisade-zone has become reduced to its normal proportions. Curved rows of short oblong cells of the same histological characters pass backwards from the chalaza and constitute the inner zone of the sclerotesta (see fig. 21, *st.*). Lying above the palisade-elements, and occupying the continuation of the plane of the gap between sclerotesta and nucellus, is a plate of not very thick-walled polygonal elements (*scl.*) stretching from the angle of confluence of the lining of the sclerotesta and the nucellar epidermis, and sharing, in common with these two layers (with which it is continuous), the characteristic blackened structureless contents. Above this layer is a considerable zone of thin-walled parenchyma (*p.*), continuous in the peripheral direction with the hypodermal tissue of the nucellus. In the direction of the entering bundle this layer all but dies out, being intercepted by the longest of the palisade-cells of the sclerotesta in this region. Nevertheless it was probably continuous with the delicate one-layered parenchyma-sheath (or possibly phloem) which accompanied the tracheal strand into the seed. The layer of thin-walled parenchyma (*p.*) is very conspicuous in transverse sections of the seed cut in this plane, and occupies a large portion of such sections.

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* Renault, 'Flore fossile d'Autun et d'Épinac,' pt. 2, p. 272.

† Cours de bot. fossile, vol. iv. 1885, pp. 184 & 186; also 'Études sur le terrain houiller de Commentry, Flore fossile,' pt. 2, 1890, pp. 669–670.

‡ Renault, 'Flore fossile d'Autun et d'Épinac,' pt. 2, p. 272, fig. 49.

§ Renault, *loc. cit.* p. 397.

‖ Brongniart, 'Les Graines fossiles,' p. 28, and pl. C. figs. 6 & 7.

¶ *Cf.* Renault, 'Cours de bot. fossile,' vol. iv. pl. 22. fig. 1, & pp. 185, 186.

The tracheal bundle which enters at the little basal papilla is slender, and runs unaltered till the thick palisade-layer is traversed. In optical section it is found to be four or five elements across, each tracheal element being very narrow ($10\,\mu$) and having rather close scalariform markings. A protoxylem was not detected. Level with the internal limit of the palisade it broadens out funnelwise, ultimately expanding into the broad tracheal plate, so usual a feature in the seeds of this period (*t.d.*). The elements composing the plate and the funnel are broad and short somewhat irregular tracheides (see Pl. **43**. fig. 21, *t.d.*, and fig. 27), and they form a close plexus: $23\,\mu \times 40\,\mu$ are average dimensions. As the margins of the plate are approached the tracheides become longer and thinner and more regularly arranged, and as we draw level with the angle where the nucellus becomes free, the tracheal sheath has assumed the characters which, as regards form of elements, dimensions, and thickness, characterise it as a tracheal sheath or mantle enclosing the macrospore in its entirety. It is a continuous sheath without trace of local segregation into bundles. In the living seed the base of the macrospore rested on the tracheal plate, as indeed is often the case in the fossil. In the case rendered in the drawing (fig. 21), the spore-wall (*m.w.*) is withdrawn some little distance, and has carried with it residues of tissue. Not far above the level shown in fig. 21 the macrospore-wall is found in close contact with the remains of the nucellus (Pl. **41**. fig. 7, *a*). Thus it appears that the delicate bundle expands into a thin but continuous sheath, which forms a complete investment to the macrospore; whilst the layer of parenchyma, which accompanies it into the seed after undergoing considerable augmentation below the tracheal plate, thins out and is continuous with the hypoderm of the nucellus.

The chalazal papilla (Pl. **41**. figs. 1 B & 7) has a diameter of $120\,\mu$; if this represent the full width of its attachment, the seed was doubtless pendulous. But it is premature to draw a conclusion until decisive evidence is forthcoming as to the existence of a sarcotesta.

The Endotesta.—For the existence of a layer interior to the sclerotesta adequate evidence exists. In Renault's figure of the chalaza * a delicate network of thin-walled cells is represented lying in the angle between the base of the nucellus and the lining of the sclerotesta, an observation confirmed by specimens that have passed through my hands. Unfortunately this network of cells is rarely preserved so as to make it possible to determine whether it was continuous with the tissues between which it lay. In the

* Renault, 'Cours de bot. fossile,' vol. iv. pl. 22. fig. 1.

majority of specimens this layer is represented by a structureless fold with occasional traces of cellular structure preserved in it. Thus in the median longitudinal section of the seed shown in Pl. **41.** figs. 1 A & B the remains of what seems to be such an inner layer are represented by the light shade (*end.t.*) between nucellus and sclerotesta. In the right-hand half of the seed the shading is continuous from the apex of the nucellus to the chalaza, and for a large part of the distance is in contact with the sclerotesta. On the left-hand side of the nucellus a similar condition obtains, though the continuity of the layer in question is less perfect.

In Pl. **41.** fig. 3 a similar fold is seen in contact with the sclerotesta lying to the left of the nucellar beak at *end.t.* A portion of this layer (*cc*) has become separated from the main part by a longitudinal fissure and lies near the pollen-chamber wall; lower down, however, this detached part is continuous with the main fold (*i. e.* with the downward prolongation of *end.t.*). Again, in Pl. **42.** fig. 13, from a somewhat younger seed, the endotesta is well shown at *end.t.*—here evidently displaced from its continuity with the sclerotesta. This preparation demonstrates, perhaps better than any other, that the endotesta was continuous with the sclerotesta. Its relations with the nucellus are obscure, but no positive evidence of its continuity with the nucellar surface has been found. The point is one of some interest, as upon it depend the relations of nucellus and testa, whether free as in *Lepidocarpon* or joined as in *Cycas.* On the whole, I incline to the former view, which is embodied in the attempted restoration given in text-fig. 1, p. 372.

The Nucellus and Pollen-chamber.

Apart from the pollen-chamber and adjacent regions, in which the main interest centres, there is little to be said about the nucellus. As in so many gymnospermous seeds of corresponding age, its whole proximal portion has become transformed into a mere pouch for the accommodation of the large solitary macrospore. We rarely find preserved (restricting ourselves to the prothallial region) more than (1) the epidermis of thick flat cells with blackened contents; (2) a narrow zone within the epidermis, the elements of which are flattened and rarely recognisable; (3) the tracheal mantle of delicate tracheides with close-wound spiral and scalariform thickenings. The inner limit of the tracheal zone abuts almost directly on the thick wall of the macrospore. The hypoderm is continuous with the parenchyma at the chalaza, and in the best specimens it is evident that it consists of several layers of cells which have become flattened upon one another. The tracheides are of various length and have an average diameter of ·01 mm. They are not readily seen in the nucellar wall, except in the very thinnest sections. When this condition is fulfilled the tracheides are found to be present in extraordinary abundance in all parts of the wall. In the aggregate they form a continuous mantle, two or three deep, from the chalaza to the pollen-chamber, and there is little doubt that they closely invested the top of the macrospore in the same way in the living seed (*cf.* text-fig. 1). Thus we find in this seed (and doubtless in some of the allied forms) a complete isolation of the inner parts of the nucellus, with the macrospore and prothallium therein contained, by a continuous sheet of tracheides. Two photographs in illustration of these tracheides are appended. Pl. 42. fig. 8, from the upper part of the prothallial region, is from a section slightly tangential in plane. Above, it shows the tracheides in the nucellar wall (*tr.*); below, where the macrospore-wall (*m.w.*) curves away to form the floor of the pollen-chamber, we see the greater portion of the tracheides lying against the nucellar wall (*tr.*^{1}), a thin layer only remaining against the macrospore (*tr.*^{2}). Pl. 41. fig. 9, on the other hand, is a completely tangential section taken at the junction of the prothallial and pollen-chamber regions. Its plane is that running obliquely down from *a*, fig. 10. At the bottom of the figure 9 the macrospore-wall is seen cut through (*m.w.*). Rising up above this for a distance of some 15 mm. (in the figure) a compact sheet of almost parallel tracheides is seen. Here they are emerging into the lower region of the pollen-chamber (supra-archegonial gap). The blank in the middle of the photograph is due to the fact that the tracheides run in a convex plane and consequently emerge from that of the section. On the flanks, however, the tracheides can be traced with little interruption till they disappear under the arching side of the pollen-chamber. The tattered cells (*ep.*) along the top and sides are the epidermal cells of this part of the pollen-chamber.

The Pollen-chamber.—We now pass on to speak more particularly of the *Pollen-chamber*. This term is rather loosely applied to the dome-shaped space occupying the distal extremity of the nucellus. In a typical case with fair preservation—as, for instance, that illustrated in Pl. 41. fig. 2—immediately upon the horizontally stretching upper portion of the macrospore-wall (*m.w.*) is a broad space contained laterally by the thin nucellar wall and tapering to an angle which lies just above the sudden curve of the macrospore-wall. Above, it is roofed over in part by a septum, of which the middle parts are wanting (*s.*). Through the broad opening where the septum is incomplete the lower space communicates with another space which occupies the apex of the nucellus. This upper chamber is the pollen-chamber, and it is here that the pollen is found; the lower chamber (*s.a.g.*), whose form approximates to that of a frustum of a sphere, is empty, except that the floor and sides are littered with tracheides with spiral thickenings. The distribution of these tracheides and their relative abundance vary from specimen to specimen. Sometimes the sloping sides of the space are plastered with them as in fig. 11, whilst on the floor there is but a sparse scattering of tracheal fragments and drawn-out spirals; or the reverse may be the case; or, finally, approximately equal shares may occur on floor and sides. In no case, however, do the tracheides extend beyond the septum. The tapering corners of the space are generally loosely filled with mutilated tracheides (Pl. 42. fig. 12, *tr.*), the actual angle of the space tapering down into that zone of the nucellar wall which is occupied by the tracheal mantle. The obvious inference to be drawn from the foregoing is that the space did not exist at all in the earlier stages of development in the living seed, and that it has been produced by the withdrawal or contraction of the top of the macrospore from the septum (or true floor of the pollen-chamber). The top of the macrospore was, no doubt, at an earlier stage overlaid with a tracheal covering which was merely a part of its general tracheal sheath or mantle (shown in the restoration, p. 372). It is the tracheal covering in this region that has become split, and the space merits the name of schizotracheal gap. The form and curvature and the occasional rupture of the macrospore-wall here are in entire harmony with such a view. Whether the development of this space (or supra-archegonial gap) occurred naturally in the living seed, or whether it only occurred on the death of the seed previous to mineralisation, will be discussed below.

The true pollen-chamber is flanked by a considerable wall of nucellar tissue (Pl. **41.** fig. 2, *sh.*) which is sometimes admirably preserved. The cells of this lateral cushion or *shoulder* are spindle-shaped, thin-walled, and unpitted, their long axes parallel to the slope of the wall (Pl. **42.** fig. 11). The surface of this cushion abutting upon the pollen-chamber is always ragged and its condition indicates that the deeper-lying tissues have broken down. The roof of the chamber consists of a stratum of collapsed and blackened cells in which it is difficult to make out any structure. The degree of preservation of the shoulder varies from seed to seed. Sometimes, as in fig. 5, the ill-preserved remains of a tissue are seen, whilst occasionally (Pl. **41.** fig. 1 A) maceration has proceeded much further. In sections which are cut at some distance from the median plane of the seed, *i. e.* tangential sections of the pollen-chamber, the shoulder appears to reach further into the pollen-chamber than is really the case (Pl. **42.** fig. 12). Between such sections and cases like that represented in Pl. **42.** fig. 13 a distinction must be drawn. In the latter, which, though slightly tangential, is not really very far from the median plane, the pollen-chamber is actually very small, and a great deal of nucellar tissue remains, not only at the sides, but below the chamber as well. This seems to indicate that we have here a somewhat younger stage in development. The supra-archegonial gap (*s.a.g.*), too, has less vertical development than in the majority of cases, whilst the splitting in the tissues to which the gap is due does not appear to have occurred quite normally. The plane of cleavage appears to have developed nearer the macrospore-membrane than usual, for (1) fragments of this membrane have remained behind on the nucellar tissue; (2) the cleft at the lateral angles is nearer the macrospore than we usually find, *i. e.* at the angles (it is the same on the right as on the left) the plane of cleavage lies below the tracheal sheath, instead of along it (*cf.* Pl. **42.** fig. 13, *x x* show the plane of cleavage at two spots).

Comparing the manner of separation of the macrospore from the floor of the pollen-chamber in younger and older specimens, it appears that whilst in the usual later stages, which form the great majority of those found, the tracheal mantle itself was the fissile layer, in the younger stage (Pl. **42.** fig. 13) there is a relatively greater cohesion between the tracheides than is the case later on. The macrospore in contracting and forming the supra-archegonial gap in these younger stages breaks away from the tracheal sheath altogether. From this it may be inferred that as development proceeded the tracheal mantle became more fissile, *i. e.* its elements in this region probably underwent a gradual solution prior to fertilisation. When, however, the macrospore separates locally from the nucellar wall along the sides or below, the fissile layer is not the tracheal mantle but the zone immediately within the mantle—precisely as in the younger stage (fig. 13). The normal condition of preservation is perhaps a result of the splitting of the tracheal layer in this softened condition. The solution of the tracheides had as a probable result the promotion of fertilisation. The actual production of a supra-archegonial gap may be regarded as a post-mortem change.

The Nucellar Beak.

The pollen-chamber is surmounted by a long canal which engages distally with the micropyle. At its base of insertion on the broader part of the nucellus this canal widens out into an inverted funnel, which overlies the pollen-chamber; but in thin median sections this funnel always presents the appearance of being detached from the wall of the pollen-chamber (Pl. **41.** fig. 1 A, *co.*, and Pl. **43.** fig. 29, *co.*). The tubular part of this structure is evidently perforated (fig. 29), whilst in fig. 3 a local swelling is shown (*p.g.*), due to a contained pollen-grain which has failed to reach the pollen-chamber. At the base of the tube the section falls just outside the cavity; higher up, the lumen is laid open (Pl. **43.** fig. 29, from just above *b* to beyond *m.*), finally the surface of the tube comes into the section showing two long rectilinear cells with carbonised contents (Pl. **41.** fig. 1 A, from the same preparation as fig. 29).

The funnel or collar is due to the sudden spreading of the sides of the tube above the pollen-chamber. It is one cell thick, and ends suddenly and always in the same way (Pl. **43.** fig. 29, *x x*, also Pl. **41.** figs. 2, *co.*, & 3, and Pl. **42.** fig. 15 *). This was evidently the case in the specimens described by Brongniart †, though his figures are not highly magnified. The cells of the collar appear thick-walled and their contents strongly carbonised. Preservation ceases abruptly at a distance of about ·4 mm. from the insertion of the tube and apparently in the middle of a cell (see fig. 29, *x x*). From this spot the collar is continued in the form of a structureless residue traceable down the flanks of the pollen-chamber for varying distances, and sometimes to the base of the seed where the space between the nucellus and sclerotesta dies out. This smear-like continuation of the collar is shown in Pl. **41.** figs. 1 A (*end.t.*) and 3. In another specimen (not figured) traces of cellular structure are apparent in the residue.

The roof of the pollen-chamber immediately below the collar has all the appearance of a tissue without its delimiting layer (Pl. **42.** fig. 14); *i.e.*, the collar is in all probability the missing epidermis which has become detached from the apex of the pollen-chamber. If this be the right interpretion, it follows that the true apex of the nucellus is beak-like and engages with the micropyle, whilst the tubular cavity of the beak is the entrance to the pollen-chamber. This view is corroborated by the specimen represented in Pl. **41.** fig. 6. This section is as nearly as possible median. The distal portion of the beak had undergone maceration prior to mineralisation, but traces of several pollen-grains which it contained are present in the micropyle (but not shown in the photograph). Of the funnel or collar, three fragments are present in the section and are distinctly visible just above the pollen-chamber. Of these fragments the two on the right are detached portions of cells of the same character as *co.* in fig. 1 A. The third fragment, shown as a tooth at the apex, is *in situ*; it has not been drawn away from the subjacent tissues.

Figure 3, from another specimen, lends itself to interpretation in the same way. Here the epidermal layer of the pollen-chamber (*e.*, *e.*) is continued up to the level from which the collar (*co.*) has been drawn away.

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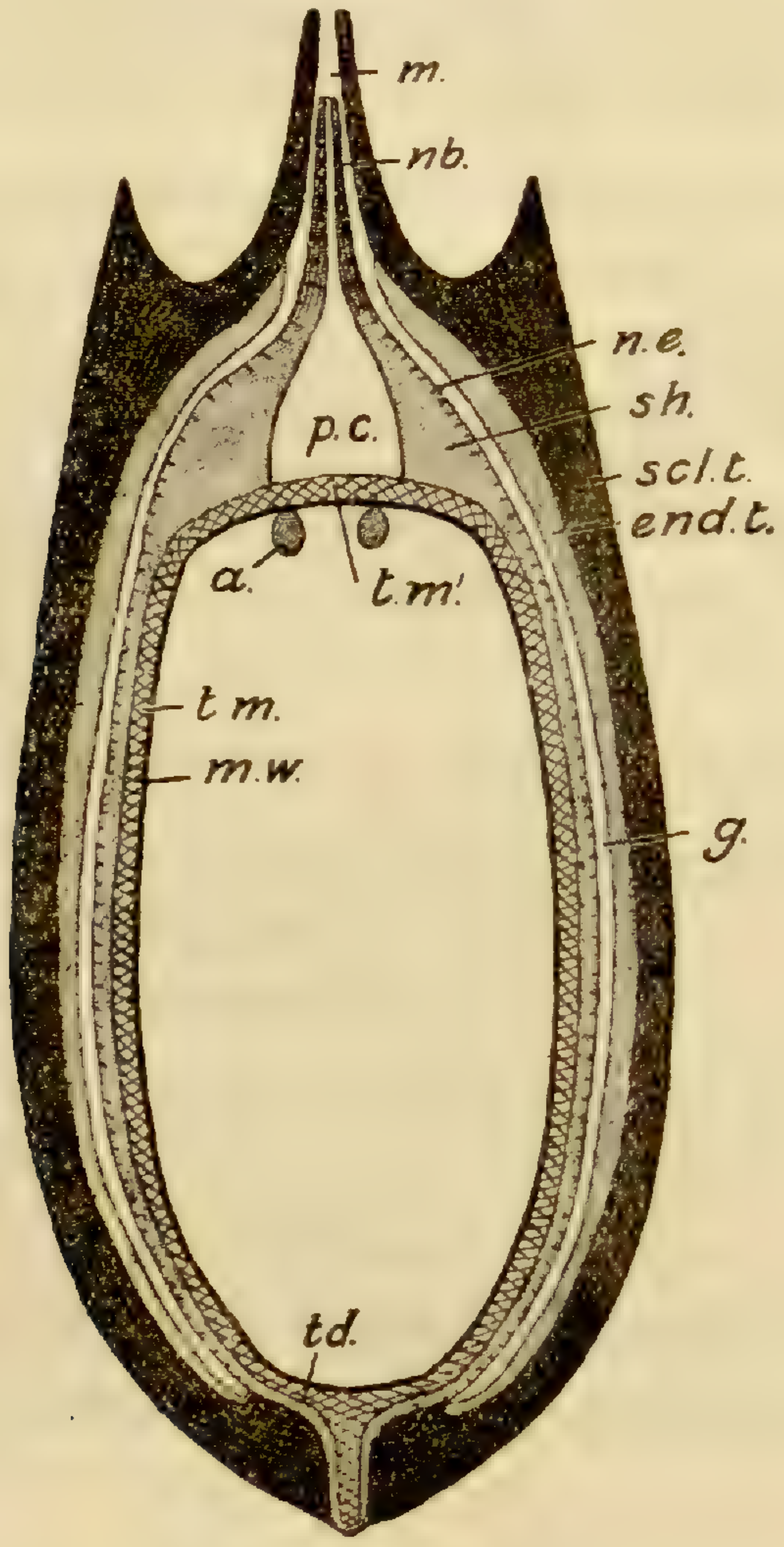
* Figure 15 should be examined with a hand-lens.

† ‘Graines fossiles silicifiées,’ pl. 16. figs. 4, 5, 7, & 9.

The reason for this severance of the beak and collar from the nucellus is to be sought probably in the fact that the nucellus underwent contraction on the death of the seed. The beak being trapped in the micropyle, with which it closely engages (Pl. 41. fig. 1 A), was unable to follow, consequently rupture occurred immediately below its insertion. The remarkable similarity to which attention has been drawn, between the detached collars of different specimens, may be interpreted as an indication of identity in the area over which the induration of the epidermal cells in this region spread. The whole phenomenon seems to accentuate the fact that the epidermis at the apex of the nucellus was peculiar and coherent, recalling the apical patch of a Marattiaceous sporangium or Cycadean pollen-sac.

Text-fig. 1.



Partial restoration of *Stephanospermum akenioides*, Brongn.

Showing the relations of nucellus and integument, the nucellar beak, and intact tracheal mantle.—*scl.t.*, sclerotesta; *end.t.*, endotesta; *m.*, micropyle; *g.*, gap between nucellus and testa; *n.e.*, nucellar epidermis; *n.b.*, nucellar beak (indurated); *p.c.*, pollen-chamber; *sh.*, shoulder of pollen-chamber; *t.d.*, tracheal disc; *t.m.*, tracheal mantle; *t.m.'*, position in which schizotracheal gap developed on death of seed; *m.w.*, macrospore-wall; *a.*, archegonium. The spongy tissue of the trough is not shown.

In this connection there is one peculiarity of preservation that requires a word of explanation. Reference has been made to the apparently structureless continuation of the collar (shown in Pl. 41. figs. 1 A, 3, and Pl. 43. fig. 29) which is occasionally to be traced to the base of the seed. Actually this continuation is not a portion of the collar at all—that is to say, the structureless residue does not indicate that a continuous stripping of the nucellar epidermis has occurred, as the latter is often recognisable still clothing the nucellus within the former.

The origin of the appearance in question seems due to the fact that when the nucellar cap was detached its broken rim became involved in the more or less macerated remains of a soft layer (the endotesta) lying between the nucellus and sclerotesta. The apparent continuity of the two structures is a secondary effect.

In the adjacent text-fig. 1 the various regions of *Stephanospermum* are represented in the relation it may be supposed they occupied in the living seed. The endotesta is represented as a lightly shaded lining to the black sclerotesta. The apical beak and collar are restored to their original position upon the top of the pollen-chamber, the probable induration of their walls being emphasized by heavier shading. Finally, the supra-archegonial gap is not represented, as its origin seems due to post-mortem fission in the tracheal sheath above the embryo-sac; this sheath is therefore shown intact.

STEPHANOSPERMUM CARYOIDES.

General Remarks.

This seed is represented by a solitary specimen which was wholly embedded in a large pebble from Grand' Croix. The block, which had already yielded a specimen of *S. akenioides* at the surface, on being broken in two in the search for other seeds was found to contain a large almost globular seed. It has been possible to obtain four complete longitudinal sections, all including the nucellus, together with some fifteen other sections through various parts. The seed is a very interesting one and apparently new; fortunately the preservation is above the average and it is possible to give a fairly full description.

Generally speaking, the relations here are as in *S. akenioides*, the chief differences being the greater size, the near approach to a globular form, and the abbreviation of the micropylar beak and peri-micropylar crown. A further point consists in the apparent strong retraction of the nucellus from the testa, so that a considerable space is left between the top of the pollen-chamber and the internal limit of the sclerotesta.

These relations are evident on glancing at the diagrammatic representation of a nearly median longitudinal section of this seed (text-fig. 2, p. 380).

The dimensions are 15½ mm. long × 12½ mm. across.

The transverse section is circular, judging from the form of the seed when exposed.

The sclerotesta has essentially the same structure as in *S. akenioides*, *i. e.* a peripheral palisade-layer and internal longitudinal layer of thick-walled cells. Internally it is defined by the usual cubical layer with carbonised contents. At the micropylar end the beak and trough of *S. akenioides* are represented by a depressed, circular, convex area, which, like the corresponding region in that seed, bears a feltwork of closely packed hairs or fibres. This region is represented in almost median longitudinal section in Pl. 44. fig. 36. The fibrous covering of the micropylar convexity seems to have a tufted insertion, bunches of hairs arising from distinct spots on the surface of the sclerotesta. Individual hairs are occasionally articulated and branched, as shown under considerable magnification in Pl. 44. fig. 37. The length of hair preserved in this seed is short, as compared with

S. akenioides (·65 mm. in *S. caryoides,* 1·6 mm. in *S. akenioides*). This difference probably corresponds with a difference in actual life in conformity with the absence of a micropylar beak. That the tuft represents a hairy plume seems improbable; its structure suggests a fibrous cushion, when some organ, now lost, may have been attached to the seed. Though there is no evidence to show that the surface of the seed was covered by a fleshy sarcotesta, there is nothing inconsistent with such a view should it seem probable from analogy with other seeds of like organisation. In this connection, however, see the remarks concerning *S. akenioides* (p. 366). The base of the most nearly median of the sections does not, unfortunately, coincide with the entering bundle, but there is no reason for supposing it to have departed materially from the type.

Endotesta.

A Layer within the Sclerotesta.—Of the existence of an endotesta beneath the sclerotesta there are some traces. There are, lining the carbonised epithelioid layer of the sclerotesta, definite traces of a thin-walled tissue (text-fig. 2, *end.t.*). These fragments are of the nature of a flattened macerated cell-reticulum, which appears to have been continuous with the epithelioid layer of the sclerotesta, but the discovery of additional specimens must be awaited before it is possible to speak confidently of the nature and extent of the endotesta in this seed.

Nucellus.

The *Nucellus* stands up freely from the base of the seed with a wide space between it and the sclerotesta. It shows the usual segmentation into prothallial and pollen-chamber regions. The embryo-sac is nearly globular, there being but a trifling difference between the transverse and vertical diameters. The pollen-chamber region is also broad and large, but its height, though actually exceeding that of the corresponding structure in *S. akenioides*, is, relative to the height of the whole nucellus, less than in that species. Here it is about $\frac{1}{7}$, in *S. akenioides* about $\frac{1}{5}$ of the whole. The summit of the nucellus tapers suddenly, *i. e.* into a short apiculus, the actual extremity of which is not, unfortunately, included in any of the sections. Consequently it must remain a matter for later determination whether the nucellar beak ended approximately as shown in Pl. **42.** fig. 17 (at *a*), as seems probable, or whether it was continued further in the direction of the micropyle. The curved sides of the pollen-chamber are included in a well-marked epidermis consisting of cubical cells on the flanks, but becoming more columnar as the insertion of the beak is approached. This is well shown in Pl. **44.** fig. 38, a faithful rendering of the top of the nucellus under a magnification of 65 diameters. The pointed summit is therefore surrounded by a circular zone of enlarged columnar epidermal cells suggesting the annulus in one of the Schizæaceæ. The sloping sides of the pollen-chamber are very well preserved in this seed, and consist of thin-walled, spindle-shaped cells, well shown in Pl. **42.** fig. 17 and in more detail in fig. 18. The long axes of these cells converge towards the apex. The walls show occasional pitting, and in the parts adjacent to the macrospore a folding of the walls, as of a tissue which had lost its turgidity previous to fossilisation. The dome-shaped cavity of the pollen-chamber is well-defined and symmetrical, its limits being marked out by the remains of its broken-down cells which had become absorbed in the excavation of the cavity. It is in this peripheral mucilage, especially, that the pollen-grains are found preserved. Their position, in a number of cases, is shown in text-fig. 2, *p.*, p^2, &c., whilst some are visible in Pl. 42. fig. 18. To this matter we shall return on p. 379. Of the cleft or gap below the pollen-chamber, so conspicuous a feature in *S. akenioides*, relatively small trace is found. A certain amount of splitting there has been, and the remains of the septum may be seen at *s.* (Pl. 42. fig. 18); the smaller photograph (fig. 17), with a hand-lens, shows it on the right-hand side as well (see also text-fig. 2, *s.a.g.*). The splitting is of the same nature as in *S. akenioides*, but less in degree. The floor of the supra-archegonial gap is practically destitute of tracheides, as are the sloping sides of this space, but the signification of this point of difference will be considered below. The main portion of the nucellus is, as usual in seeds of this period, reduced to a sheath or pouch enclosing the large macrospore. Similarly, an epidermis—well-defined, though at places detached from the nucellus—is present; at the chalaza it becomes continuous with the epithelioid lining the sclerotesta (text-fig. 2). As stated above, though the entering bundle is not included in any of the sections, there is no reason for supposing that it differed from that of *S. akenioides*. In the chalazal region of the nucellus there are ample remains of an extensive tracheal plate, the margins of which are continued up the nucellus as an unbroken sheath of tracheides, traceable up to the insertion of the sides of the pollen-chamber (text-fig. 2, *b*). The layer of tracheides lies just within the surface of the nucellus; between it and the epidermis are the compressed remains of a soft peripheral layer. In other words, the relations here are essentially as in the allied species. At one spot near the chalaza a large fragment of the nucellar wall has splintered away and been drawn into the cavity of the embryo-sac (Pl. 42. fig. 17, *f*). This is repeated in all three of the more median sections and is not due to shattering. The fragment of the macrospore and nucellar wall was evidently displaced anterior to mineralisation and in this position it has become embedded. The tracheides of this splinter have become somewhat fretted out and are in some degree isolated. They are unusually large and well preserved, and form most beautiful microscopic objects. Pl. 44. fig. 39 shows a group, whilst two of the tracheides are represented in Pl. 42. fig. 19. The rib-like thickenings of the walls show an unusual perfection of preservation. Occasionally the scalariform type gives place to a reticulated thickening as in fig. 39.

The average diameter of these cells is 20 μ, so that they are much larger than in *S. akenioides* (where the diameter is about 14 μ). This type of tracheide forms a continuous sheath of closely packed elements in the nucellar wall, some three deep, traceable to the insertion of the pollen-chamber, where they die out (text-fig. 2, *b*). It may be conjectured that on the top of the embryo-sac they have been absorbed, a change which, apparently, likewise took place in *S. akenioides* (*cf.* p. 370), where in older seeds they are sometimes less easy of observation and occasionally wanting altogether. That the solitary specimen of *S. caryoides* corresponds to a stage slightly older than the commonly occurring type of *Stephanospermum* there is good reason to suppose (*cf.* below, p. 387).

The Structure of the Pollen.

This part of the subject has been reserved for special consideration, and the observations drawn from the two species of seeds are given consecutively.

(1) *Pollen of* Stephanospermum akenioides.

In almost every pollen-chamber of this seed the characteristic pollen, so often mentioned by Renault, is present. These grains are usually congregated together in the apex of the chamber, as in Pl. 41. figs. 2, 3, 6, and Pl. 42. fig. 15. It is only exceptionally that a grain has been drawn down to the level of the diaphragm (*d.*) (as in fig. 3, $p.^1$) or below it, as with the isolated abortive grain ($p.^2$) in the same photograph. The majority of the grains are large, possessing average dimensions of $160\,\mu \times 100\,\mu$, whilst occasional grains reach a length of $200\,\mu$ or even $210\,\mu$ (figs. 6 & 15). With these larger grains others of the same type are present, having an average length of $100\,\mu$. These may be regarded as grains which have failed to develop after reaching the chamber. In but a solitary instance has foreign pollen been found in the chamber. This case is illustrated in fig. 15, where, in addition to the large normal pollen-grain, two small grains are seen lying in the apex of the chamber just above it, whilst a third overlies its left-hand extremity. The upper left-hand grain shows a longitudinal furrow and is doubtless "foreign"; so, too, is its right-hand neighbour, but referable to the Cordaitean type; the third little grain is of the same nature. All these foreign pollen-grains seem to agree in remaining abortive, contrasting in this respect with the true pollen of *Stephanospermum*, which has undergone further development is this pollen-chamber.

The normal pollen shows an external finely granulated or sculptured coat, the exospore, whilst the contents are divided into a tissue of many cells. In this point of the multicellular nature of the pollen, concerning which there has been some question, I find myself in complete agreement with Renault, who described the grains in his 'Cours de bot. foss.' vol. iv. p. 185, and has adhered to his interpretation consistently ever since. The internal cells line the exospore everywhere, and surface views of the grains show the whole area mapped out by this internal tissue as in Renault's figures *, and here in Pl. 42. fig. 15 and in fig. 14, *p.*

A study of sections of the grains confirms the conclusions obtained from surface views. Pl. 42. figs. 14, $p.^2$, and 16, $p.^2$, represent a section of the same pollen-grain cut at right angles to its major axis. Here we are looking into the grain without the intervention of the surface, *ex.* (fig. 16) being the cut edge of the exospore. Within the grain, which is unusually well-preserved (fig. 16, $p.^2$), a system of three convergent radial walls is evident. The internal organisation of this grain is further elucidated in Pl. 43. figs. 30 and 31. Fig. 30 is a view of the cut surface magnified about 180 diameters. The cut edge of the exospore (*ex.*) is seen as in fig. 16, and the three radial walls *a*, *b*, and *c*; traces of two more, *d* and *e*, are also discernible. Fig. 31 is an optical section of the same grain from a deeper plane and shows the walls *a*, *b*, *c*, and *d* as complete membranes, whilst *e* is broken. From a study of this and similar preparations it would appear that there were about five rows of wedge-shaped cells disposed symmetrically about the longer axis of the grain. Turning now to a longitudinal section of a grain, we may consider in detail that marked *p.* in Pl. **41.** fig. 6. The details are fully illustrated in Pl. **44.** figures 32, 33, and 34. This grain is not cut in actual longitudinal section, but it is very nearly so. Figs. 32 and 34 represent the grain as seen from above and below respectively. The exospore (shaded) and its cut edge are evident in both figures, as also are the remains of the internal system of cell-walls, laid open by the section. Fig. 33 represents an optical section lying between the views rendered in figs. 32 and 34. Here are shown some eight cells lying around a central space (*c*) in which rests a dark nucleus-like body (*n*). The walls of the lining cells here show a copious perforation (as at *w*, fig. 33).

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* Notice sur les travaux scientifiques de M. B. Renault, 1896, pl. 6. fig. 8; Cours de bot. foss. iv. pl. 21. fig. 9.

Another longitudinal section is represented in fig. 35, a drawing of pollen-grain $p.^3$ (Pl. **42.** figs. 14 & 16). As before, the cut edge of the exospore is shown (*ex.*) with traces of the internal cells (*c, c*), whilst in the middle of the figure is a spider-like body (*cb*), no doubt the same as *n* in fig. 33, but better preserved and also more typical—at any rate in the sections which have passed through my hands. The relation of the "legs" of the "spider" to the peripheral cells is suggestive, whilst at one place (*b*) the central body is continuous with the membrane.

The interpretation which may be placed on all these appearances (*i. e.*, those shown in figs. 30 to 35) is as follows:—The pollen-grain contains some five rows of internal cells (making some twenty cells in all), somewhat wedge-shaped in form, with the tapering apices of the wedges directed inwards. These cells, prior to mineralisation (whether in life or death is uncertain), underwent a certain degree of separation from one another at the centre, a separation which involved a fracture of the walls in that region. In this way there was left behind a sort of replum, which has been compared to a nucleus in fig. 33, and to a spider in fig. 35. This replum is far from uncommon. The transverse section (Pl. **42.** fig. 16, $p.^2$, and Pl. **43.** figs. 30 & 31) is perhaps not cut quite across the equator of the grain, but may coincide with a plane a little nearer one pole, as indicated at *d*, fig. 35. Finally, the pollen-grain $p.^1$, in fig. 14, is cut in transverse section, the transverse zone corresponding to that which would be included between the planes *e* and *f*, fig. 35. This section, according to the focal plane examined, shows either a free spider-like body or a condition of affairs resembling figs. 30 and 31. It thus removes all doubt as to the nature of the central body or "replum," which consists of the coherent internal margins of the septa.

Recently, M. Renault * has directed attention to the pollen-grains of *Stephanospermum akenioides* and *Ætheotesta*. In both cases the grains are similarly organised, *i. e.*, many peripheral cells surrounding a central space, which often contains a nucleus-like body. In the case of *Ætheotesta* the grain is described. To quote the passage †:—"Celles-ci" (*i. e.*, the peripheral cells) "paraissent groupées assez régulièrement autour d'une cellule axiale tardive, où se trouve un noyau ? mal defini, appartenant peut-être à un Anthérozoide. Dans la région polaire on remarque un bourrulet circulaire *t.p.* *, se prolongeant en un tube court et représentant les restes d'un tube pollinique ; autant qu'on en peut juger par transparence, ce tube serait en relation avec la cellule axiale." And further, "Il ne serait pas invraisemblable que les gros grains de pollen des *Stephanospermum* et des *Ætheotesta* aient ainsi produit un tube pollinique permettant la sortie des Anthérozoides emprisonnés dans une enveloppe épaisse et résistante."

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* "Sur quelques pollens fossiles," Soc. d'Hist. nat. d'Autun, Séance du 13 juin, 1901. "Sur quelques Cryptogames hétérosporées," *ibid.*, Séance du 22 sept., 1901.

† From the paper of Sept. 22, 1901, p. 7.

In regard to *Ætheotesta* no comment is called for here, as this seed has not come under my observation. As regards *Stephanospermum akenioides* I have described in detail the critical preparations. That the body in the central space is nuclear in nature seems open to question, as indeed does the cellular nature of the space itself. It would seem possible that M. Renault may have had under observation pollen-grains of *Stephanospermum akenioides* sharing a condition of preservation corresponding to that represented in Pl. 44. figs. 32, 33, & 34. This, taken in connection with a tube-like orifice attached to one pole in the case of *Ætheotesta*, obviously suggested the inference which M. Renault draws, evidently with some reserve.

It may be pointed out that papilla-like outgrowths are not infrequent on the pollen-grains of *S. akenioides*, but they are not localised to a pole or any other spot in particular. One such is readily seen with a hand-lens on the lower side of the large pollen-grain in fig. 15. Another is present on the same grain immediately behind the foreign pollen-grain, and, of course, not shown in the photograph. The length of these little tubes does not exceed 20–25 μ. Whether they be mere accidents of preservation or the simple pollen-tubes of unspecialised multiple pollen-grains must remain, for the present, an open question.

Some allusion has been made to the perforation of the dissepiments in the interior of the pollen-grain. That they were abundant is seen from fig. 33, *w*. The raggedness of the walls cut in section, both here and in figs. 32 and 34, is due to the same cause. That these perforations are in any way connected with the liberation of possible antherozoids, can only be a matter of conjecture. The contents of the cells are not preserved in any of the specimens of *S. akenioides* that have passed through my hands. On the other hand, the fenestration of the walls may be readily conceived as the result of post-mortem, bacterial, or other destructive agency. Perforations of that kind are common enough in cuticularised epidermal membranes, parenchyma, &c. in the Grand' Croix pebbles. It is quite possible that in this species the seeds are preserved at a stage anterior to that at which antherozoids were liberated. But in any case the perforation of these internal walls is not wholly intelligible on any hypothesis of dehiscence ; for, in addition to actual tubes, large openings are found in the outer wall of the grain, quite adequate for the exit of antherozoids. These have been figured by Renault † for *Dolerophyllum*, and attributed by him to bacterial agency ; those produced here are in essential agreement. The only inference that can be safely drawn respecting the holes in the internal walls is that the walls of the pollen-grain complex were readily destructible, and adapted to freeing antherozoids if the necessity arose. In old-looking and probably much macerated pollen-grains, such as are occasionally to be observed, the whole system of internal walls appears to have broken down, leaving (in the rarest instances) what may possibly be small complexes of secondary cells. It is possible that here we have an indication of the formation of antherozoid mother-cells in considerable number in each. However, adequate data are lacking for a satisfactory hypothesis in this species. The subject will be alluded to again on p. 385, when dealing with *Stephanospermum caryoides*.

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* This refers to a figure showing a pollen-grain bearing a small excrescence at one pole.

† 'Flore fossile d'Autun et d'Épinac,' p. 269.

Renault has concluded that the pollen in this, as in other cases, underwent considerable growth in the pollen-chamber where it matured. He compared the dimensions of *Stephanospermum* pollen scattered in the matrix with that in the pollen-chamber, and infers a growth of about one third *.

As already stated, I have found numerous abortive grains present with the normal large grains in the pollen-chamber, and also, in certain cases, grains that have remained trapped in the micropyle.

I append a summary of the dimensions of these various grains, which wholly corroborates the view of M. Renault :—

Pollen-chamber shown in		
Fig. 3	Average length of three normal grains in the pollen-chamber	180 μ.
Fig. 3	Ditto of five abortive grains	100 μ.
Fig. 6	Average length of three normal grains in the pollen-chamber	150 μ.
Fig. 6	Ditto of five trapped in the micropyle	66 μ.
Fig. 2	Length of largest grain	200 μ.
Fig. 15	Length of the large grain	210 μ.
General average of length of pollen-grains of this species scattered in the matrix		60 μ.

(2) *Pollen of* Stephanospermum caryoides.

In the pollen-chamber of this seed eight pollen-grains or portions of pollen-grains have been found. They occur either attached to the lining of the chamber or very near to it. For convenience, the positions of seven of these bodies are represented in text-fig. 2, p. 380 (*p.*–$p.^6$), as though they all occurred in a single section. They are really present in three sections, but for convenience of reference they are projected on to one plane. The eighth grain, which shows nothing, has not been included. The whole of these bodies appears to belong to one sort of pollen, a conclusion based on the dimensions of the various parts and on the nature of the sculpturings of the exospore ; and as they show various developmental stages, and none of them is abortive, it is exceedingly probable that these grains really belong to the seed in the pollen-chamber of which they occur †.

Of the bodies mentioned, two are complete pollen-grains ; the rest, fragments apparently in various phases of development. *p.* and $p.^2$ (text-fig. 2) are pollen-grains ; $p.^1$, $p.^3$, $p.^4$, $p.^5$, and $p.^6$ isolated internal cells of pollen-grains.

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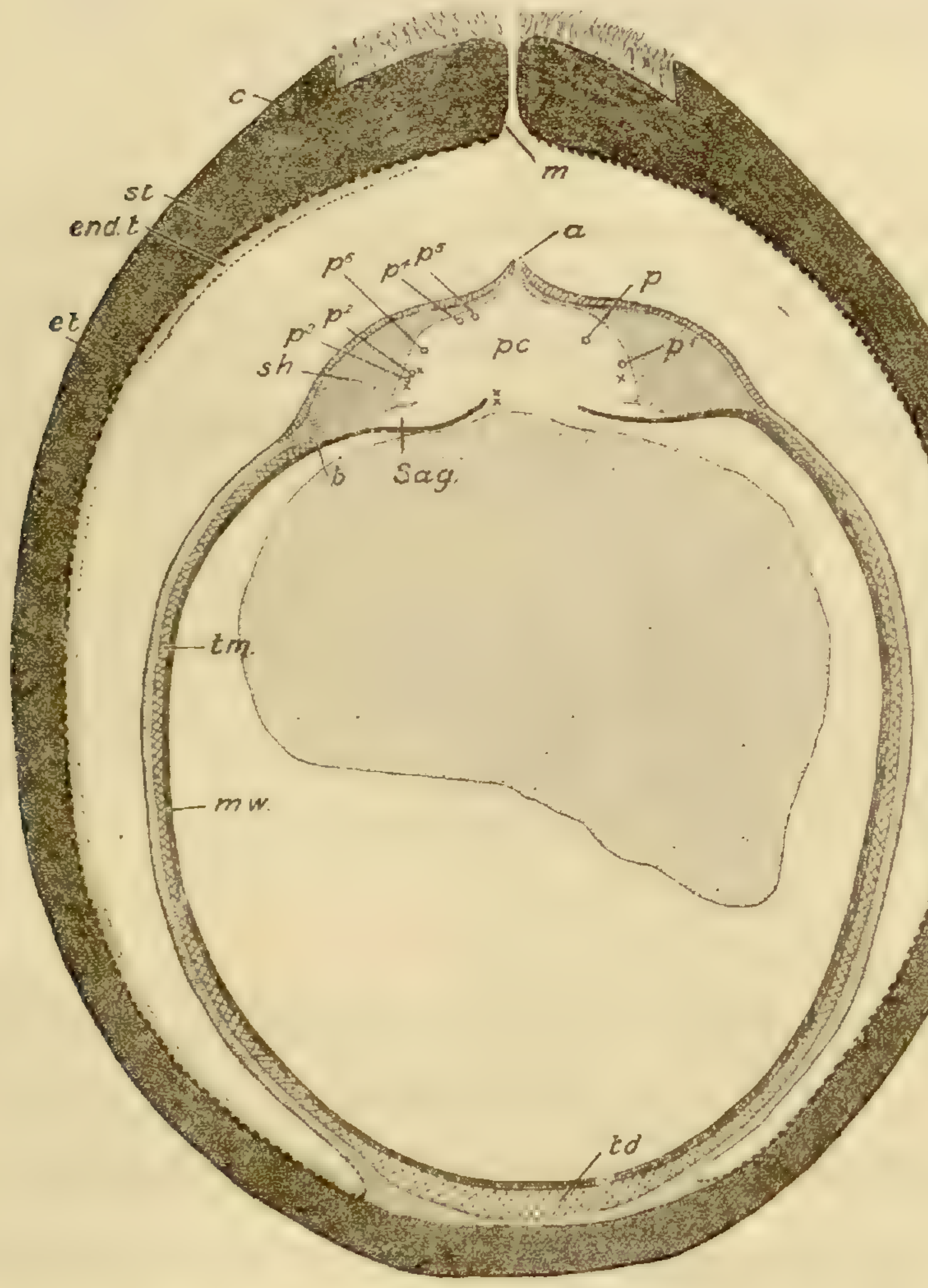
* 'Cours de botanique fossile,' vol. iv. p. 185.

† Unfortunately a second specimen is not available to test this assumption.

(a) *Complete Pollen-grains.*—The external features are shown by the grain *p.*² (text-fig. 2, and Pl. 44. fig. 42). It is oval and evidently flattened in the plane of the section. Its dimensions are 91 $\mu \times$ 72 μ. Its area is divided into a peripheral gently convex region and a central strongly convex boss. Both the wing-like periphery and the central boss are sculptured. The former is marked with radially running lines, the latter with a reticulated sculpturing (fig. 42, *p.*²). The grain is marked with a triradiate slit (fig. 42, *tr.s.*) on the convex central region, possibly an indication of its origin as a member of a tetrad.

Text-fig. 2.



Median longitudinal section of *Stephanospermum caryoides.*

Outside is the integument or sclerotesta (*st.*), with its epithelioid lining (*et.*); within it, fragments of the endotesta (*end.t.*) are represented; *m.*, micropyle. The broad nucellus contains the pollen-chamber (*p.c.*) above, *a* marking its apex; *sh.*, peripheral tissue (shoulder) of pollen-chamber with well-marked epidermis; *p.*, *p.*¹, &c., the various pollen-grains referred to in the text; × ×, position of possible antherozoids; *s.a.g.*, supra-archegonial gap; *t.m.*, the tracheal mantle, ending at *b*; *t.d.*, tracheal disc; *m.w.*, wall of macrospore. × 6½.

This pollen-grain is rather opaque, but details of the internal structure are provided by *p.*¹, represented in fig. 40 (dimensions of *p.*¹, 110 $\mu \times$ 75 μ). In this grain parts of the boss have been ground away in the preparation of the section. Focussing through the boss two internal cells are distinctly seen (*a* & *b*, Pl. 44. fig. 40), a smaller cell and a larger one partly surrounding it. The contents of the larger cell (*a*) seem to be preserved. The irregular space *c*, at the right-hand bottom corner of the grain, appears to be an extension of the outer cavity of the pollen-grain—to be a pollen-tube, in fact. Two alternatives to this view are possible. First, that a fragment of the matrix has splintered away in the grinding of the preparation. This interpretation is untenable, as the matrix is actually present at *c*. The other alternative is that the excrescence is an accidental blister that originated prior to mineralisation *. As there is no means of determining from this isolated example whether the outgrowth was a natural or an accidental production, any conclusion as to its nature must be based on other considerations. Before this is possible the remaining stages have to be considered. Whatever may have been its nature, this tube was not very extensive. If we assume that the tube curved out of the plane of section, we should expect to find it in one of the two adjacent sections, if the appropriate regions be examined. No trace of it, however, is to be found. The tube consequently was of very limited extent. In the preparation it reaches to a distance of 22 μ from the pollen-grain. Traces of the triradiate slit are also present (Pl. 44. fig. 40, *tr.s.*).

(b) *Isolated internal Cells.*—The pollen evidently underwent some process of partial dissolution or rupture, for the isolated internal cells, agreeing approximately in dimensions with *a* and *b* of fig. 40, are common in the pollen-chamber. Those of importance to this account are shown at $p.^1$, $p.^3$, $p.^6$ (text-fig. 2).

$p.^1$—This is represented in fig. 41, and corresponds in dimensions ($40\ \mu \times 30\ \mu$) to the larger internal cell (*a*, fig. 40). It is still enclosed by the reticulated exospore of the convex part of the pollen-grain, and at *w* appears to show a small portion of the radiating sculpturing belonging to the flatter portion of the original pollen-grain. Within, a four-celled complex has been developed. These secondary cells show no contents. They have an average diameter of 15 μ. The containing (sculptured) membrane of the complex is incomplete above, but the walls of the secondary cells appear to be complete.

$p.^3$—This pollen-fragment consists of the pair of internal cells shown in fig. 42, $p.^3$. The cells are still joined together, but their original relations in the pollen-grain seem to have undergone a slight alteration by the outward rotation of *b* from *a* (fig. 42) in the direction of the adjacent pollen-grain $p.^2$ The close association of *a* and *b* with this pollen-grain seems to be purely accidental—$p.^2$ is intact, *a* and *b* are the remains of another pollen-grain. The two joined cells of $p.^3$ are laid open and present their concavities. Each contains the remains of a secondary cell-complex: that in *b*, relatively well-preserved (*b*, fig. 42), and somewhat displaced in relation to its containing membrane; that in *a* only recognisable as a crushed cell-group at *c* (fig. 42). Pl. 42. fig. 20 represents the cell-complex lying in the containing cell *b*, taken direct from the specimen.

The dimensions are as follows:—*a*, $37\ \mu \times 25\ \mu$; *b*, $31\ \mu \times 25\ \mu$. The larger cells of the reticulum contained in *b* have a diameter of about 15 μ.

$p.^6$—By itself, little importance would attach to this fragment. It consists of a broken containing-membrane with the remains of a possible secondary tissue lying close beside it; it is not figured.

$p.^5$ essentially resembles $p.^1$, but is less well placed for observation.

From the foregoing exposition of the facts concerning the pollen-grains and pollen-fragments occurring in this pollen-chamber, it appears evident (1) that the pollen-grains, originally containing two internal cells and an extensive undivided residue (as shown in fig. 40, and as may be gathered also from scattered grains in the matrix), underwent a process of dehiscence by which the internal cells were liberated; (2) that the two internal cells concurrently produced secondary cell-complexes which may be regarded provisionally as antherozoid mother-cells. So far as the stages that have been found are concerned, the manner of freeing of the internal cells is obscure. That stage is wanting.

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* A slight blistering has been observed in occasional instances in Cordaitean pollen-grains lying freely in the matrix.

We may now return to *p.*, the pollen-grain represented in Pl. 44. fig. 40 with tube-like outgrowth, and consider whether it helps to bridge the lacuna in our series. Assuming for the moment that it is a naturally produced tube, it is easy to realise (from the point of view of the preservation of the pollen-fragments) that it may have constituted a weak spot from which decay may have started on the death of the seed, a decay which ultimately involved the whole peripheral part of the pollen-grain. Or, the changes in the outer cell of the pollen-grain which led to the production of a tube may have involved the whole of the peripheral part of the wall of the grain in decomposition. This is one hypothesis. On the other hand, it must be borne in mind that a solution of this part of the wall might have been achieved without the production of any tube. Finally, there is a third possibility. The triradiate mark or crack on the pollen-grain $p.^2$, represented also on *p.* (fig. 40, *t.r.s.*), and occasionally present on these grains in the matrix, *may* have offered the means of dehiscence, though the possibility seems a remote one. It is true that fern-spores with triradiate ridges use these lines for dehiscence at germination *, but there is no reason for supposing this method to have been perpetuated in seed-plants †.

But however this may be, it does not touch the present case, for the question is how the pollen-grains come to lose their wing-like expansions. The detached internal cells still bear their covering of exospore on one side. The decision arrived at depends on the view taken of the tube-like outgrowth in fig. 40. If this is a genuine tube (however rudimentary), then the structure of the grain would be intelligible. The outer cell is concerned in the production of a short tube through which the antherozoids, which may be supposed to have arisen in the secondary complexes (shown in $p.^3$, fig. 42), were discharged. On this view the grain is differentiated into a generative portion consisting of the two internal cells, and a directive portion which developed a tube and perhaps started the antherozoids in the right direction.

Having traced events so far, we may pass on to the more conjectural question of the antherozoids themselves. In what is doubtless the fossilised mucilage of certain regions of this pollen-chamber, bodies are preserved which are susceptible of interpretation in this sense. The bodies in question are small ovoid vesicles having as average dimensions

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* See Sadebeck, in Schenk's 'Handbuch d. Botanik,' vol. i. p. 154.

† See Coulter & Chamberlain, 'Morphology of Spermaphytes,' p. 91, fig. 69, *c*. The pollen-grains of *Pinus Laricio* are shown in the tetrad condition. From the position of the sac-like blisters of the extine, it would appear that the pollen-tube will arise on the side of the pollen-grain remote from the contact-angles of the members of the tetrad.

$17\,\mu \times 15\,\mu$. Two of them are represented in Pl. 44. fig. 13. Their position in the pollen-chamber is indicated by two little crosses close to the rent in the macrospore-wall (text-fig. 2, p. 380). Each body is delineated by a delicate membrane whose contour is slightly indented or crenate, the convexities of the crenations being directed towards the centre of the body. Within this membrane is a slightly carbonised reticulum, which may perhaps be regarded as the nucleus. Such types of nuclear preservation are sometimes met with in the cells of the female prothallium. Of cilia attached to these bodies there is no trace, though the radiate zone or halo of crystallisation occasionally found around them is not without some resemblance to a halo of cilia.

Whilst the size of these bodies supports the view that they may have escaped from the cells of the secondary complexes of the pollen-fragments, and their distribution, described below, is that which might be expected were they antherozoids, it is evident that in their actual preservation they do not closely resemble the antherozoids of any known Pteridophyte or Cycad. Traces of the spiral band are lacking. So far as general form is concerned, they are Cycadean rather than Filicinean. In their dimensions, however, they approach the Ferns. No positive determination is possible till similar and better preserved bodies of the kind have been studied in other specimens. The supposed antherozoids, oval in form, have a peculiar distribution. Three occur in the mucilage above the ruptured spot, and others at the spots indicated by small crosses in text-fig. 2. Of their distribution, it may be said that the antherozoids are met with either in the neighbourhood of those spots at which it is reasonable to suppose (in view of the other evidence) that antherozoids were liberated, or in the neighbourhood of the female prothallium, and nowhere else. Their dimensions harmonise with those of the secondary cell-complexes of the pollen-cells.

Though there seems little reason to doubt that the bodies in question represent nuclei enclosed in loose crenate envelopes, it must be borne in mind that the pollen-chamber itself has, no doubt, become excavated by a lysigenous breakdown of the tissues, and it would be difficult to prove that our nuclei may not have originated in that way. Or, again, it is possible they may be the free spores of one of the Fungi known to have attacked the tissues of the nucellus in more than one of the Palæozoic seeds. The most striking facts about them are their size and distribution. The attribution of these structures to antherozoids is conjectural, but the facts seem to justify allusion to them. Even if this seed were recent and not fossil, their occurrence would need further study and confirmation. In the present case, where so many pitfalls beset the investigator, such corroboration is, of course, more urgent.

The Question of Pollen-tubes.

If we look at the question from the wider standpoint of all the facts that have been so far elicited, how does the matter stand? In the case of the pollen of *Ætheotesta* we have Renault's interesting observation of a funnel-like process at one pole of the grain *. In *Codonospermum olivæforme* † the pollen-grains (stated to be derived from *Dolerophyllum*) are provided with an operculum. In both cases the indication would seem to be that there was a certain local specialisation in connection with the discharge of the antherozoids. From a study of the structure of the pollen of *Stephanospermum akenioides*, Renault conjectures that a state of affairs may exist corresponding to *Ætheotesta*. I have endeavoured to show (p. 378) why such an interpretation of *S. akenioides* seems inadmissible. If the little tubular processes occasionally found projecting from the periphery of these grains (as in the large grain, fig. 15) be indeed naturally formed, the inference I would draw would be that this pollen was of a more generalized type, and that any of its cells could produce these tubes. In other words, that short multiple pollen-tubes were formed through which the antherozoids were discharged. As compared with this type, *Ætheotesta* and *Codonospermum*, each in its own way, shows a slight advance without departing from the *Stephanospermum*-type of pollen. Coming to *Stephanospermum caryoides*, reduction and specialisation are more complete. A considerable part of the pollen-grain remains undivided, as in recent Gymnosperms. This outer cell, whilst it may have possessed nutritive functions in connection with the maturing of the antherozoids, was doubtless concerned in promoting their discharge into the pollen-chamber. Whether this result was achieved through the agency of an incipient tube, as suggested by our preparation, or whether the internal cells were liberated through the deliquescence or dehiscence of the outer cell, must remain an open question till more evidence accrues.

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* 'Sur quelques Cryptogames hétérosporées,' p. 7, and fig. 13, p. 5.

† Renault, *loc. cit.* p. 7, and fig. 14, p. 5.

The internal complexes of cells in the pollen of *Stephanospermum akenioides*, of *Cordaites*, and of *Stephanospermum caryoides* may thus represent different stages in the reduction of an archaic male gametophyte of a complexity not known in any Fern. It is true that the reticulations of the supposed "microspores" in *Botryopteris* and *Zygopteris* have been interpreted as an internal tissue *, thus offering an easy transition to the compound pollen of the early Gymnosperms. To this view of the reticulations there seem to be grave objections, and, after careful study of specimens, it is difficult to avoid sharing the doubt which has been expressed † whether these "microspores" justify the interpretation to which allusion has been made.

The main obstacle to definite and certain conclusions as to the behaviour of the pollen in these seeds is, of course, the fact that the seeds fell from the tree at a stage in development prior to fertilisation. The conditions are somewhat analogous to those that would obtain in the case of *Pinus sylvestris* were only first-year cones available for investigation. The mode of transport of the sexual cells is not yet fully declared. Nor, indeed, in *Stephanospermum akenioides*, do we know with certainty which *are* the sexual cells. The preparations that have come under observation, however, seem to indicate decisively that the "central body" is *not* of this nature (*cf.* p. 377). Of the twenty or more peripheral cells which compose the grain, it is impossible to select any as differing from the rest. They are all alike. Occasionally, short tubes are found—spout-like outgrowths from some of these cells. But their occurrence is too occasional as yet for acceptance as a normal stage in development. That pollen-tubes were produced penetrating the nucellar tissues as in recent Cycads and Conifers appears highly improbable. The pollen-grains of *Stephanospermum*, large from the first, have already, in the stage usually preserved, sojourned in the pollen-chamber for a considerable time, and have there undergone a further development. Had they formed rhizoid-like attachments to or actual tubes in the tissue of the wall of the chamber, indications could hardly be wanting. It may, I think, be safely assumed that structures of that kind were not produced. That mobile antherozoids were liberated in *Stephanospermum* may be inferred with some degree of confidence from the whole organisation of the pollen-chamber. Whether all or but a part of the internal cells of the pollen-grains were concerned in the production of antherozoids, there is no evidence to show. That papillæ (as in Pl. **42.** fig. 15) arose from the periphery of these cells, liberating antherozoids, is not inherently improbable. To the occurrence of perforations, whether on the surface of the grains or, as is so frequently the case, on their partition-walls, just this significance may be attached, viz., that these walls were readily destructible, and that consequently a very limited number of papillæ might have served for the discharge of all the antherozoids produced in one of these multiple pollen-grains.

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* 'Flore fossile d'Autun et d'Épinac,' pp. 44, 54, 57.

† R. Zeiller, 'Éléments des Paléobotanique,' 1900, p. 74.

The view which I adopt in regard to this seed is that no tubular, rhizoid-like attachments were formed by the pollen-grains on the walls of the pollen-chamber, but that the large grains, after a process of maturing in the chamber, liberated antherozoids by some simple means, such, perhaps, as the extrusion of short papillæ, the tips of which became perforated. Finally, that the antherozoids were formed in considerable numbers and that the distance they had to traverse by swimming was relatively great—as compared with recent Cycads, for instance.

In *Stephanospermum caryoides* the number of primary internal cells is much reduced. They are partly enclosed in an extensive peripheral cell recalling the tube-cell of the pollen of recent Gymnosperms. The two internal cells produced secondary complexes of antherozoid mother-cells, whilst the outer cell seems to have facilitated the liberation of the antherozoids. Whether the blister-like outgrowth (*c*) of Pl. **44.** fig. 40 indicates the natural means of exit of the antherozoids must remain an open question till additional specimens are available. In this seed, as in *S. akenioides*, the freedom of the pollen from special nutritive relations with the tissues of the nucellus seems to mark an archaic condition not preserved in any recent Gymnosperm. The discovery of this seed in a stage of development apparently more advanced than any of the numerous specimens of *S. akenioides* that have passed through my hands, encourages the hope that the phenomena attendant upon fertilisation in the seeds of this period may ultimately become known to botanical science.

The Difference in Pollen-structure.

From the description which has been given of the pollen-grains in the two *Stephanosperma*, it is evident that considerable divergence exists in their complexity in these two seeds. Whilst in the former the pollen-grains are filled with a tissue of some twenty cells or more, in the latter is contained a group of two. If, therefore, the close association of the two seeds be justified, as I incline to think on the near agreement of their general characters, it follows that a considerable latitude in pollen-structure may co-exist within a fairly close cycle of affinity. Hitherto, two types of pollen have been recognised, the *Stephanospermum* (*akenioides*)-*Codonospermum*-type, filled with cells, and the Cordaitean type, in which there is an isolated prothallial or antheridial group*. It is premature to say whether the former type corresponds generally to the radially organised seeds of this period, the latter to the flattened. The problem does not appear to have been worked out in detail. The existence of a case like *S. caryoides*, where the pollen conforms rather to what I have referred to as the Cordaitean type, seems to indicate that seed- and pollen-structure do not run parallel in the two cases, and that the relations of the two broadly contrasting groups of seeds may be more complex than seemed probable.

Actually, the pollen of *S. caryoides* differs considerably from that of *Cordaites*. The primary internal complex of two cells (which is shown both in the matrix and in the pollen-chamber) would seem to mark a reduction from the Cordaitean type. Whether the secondary complexes, which later on appear within these primary cells in *S. caryoides*, represent merely a postponement in the appearance of elements present in *Cordaites*, even before escape from the pollen-sac, it seems hardly profitable to discuss in the present imperfect state of our knowledge.

CHARACTERS DISTINGUISHING STEPHANOSPERMUM CARYOIDES, n. sp.

STEPHANOSPERMUM CARYOIDES, n. sp.

This supposed new seed resembles *S. akenioides*, Brongn., in being circular in transverse section and in the possession of an apical crown and micropylar beak, though in an abbreviated form. As in that species, the perimicropylar area is closely set with hairs. Another feature in which the seeds agree is the continuous tracheal mantle of the nucellus.

S. caryoides is a large seed, approaching a globular form. Length 15½ mm.; diameter 12½ mm.

Its pollen-chamber is large and broad, with well-developed shoulders.

The peculiarities of the pollen have been noted above.

ON FERTILISATION AND THE TRACHEAL MANTLE.

The course in the foregoing seeds during life may be supposed to be somewhat as follows:—The pollen is caught at the apex of the ovule by a drop of mucilage which in any case must have been secreted here. There is no evidence to show what was the source of this drop, whether it welled up from the nucellar apex or was secreted at the micropyle. As the pollen-chamber developed and assumed the character of an extensive excavation in the nucellus, the peripheral tissue became sharply delimited from the central deliquescent area and formed the "shoulders." This flank or shoulder no doubt served the purpose of holding up the roof of the pollen-chamber, so that it should not collapse—a function apparently discharged in quite another way by Hirase's "tentpole" in the case of *Ginkgo*, and by the central cone of nucellar tissue in *Lagenostoma*.

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* *Cf.* Renault, 'Flore carbonifère,' 1879, pl. 17. fig. 15.

During the later stages of development the pollen has been maturing and has undergone considerable enlargement. The internal cells of the pollen underwent a subdivision into antherozoid mother-cells in *Stephanospermum caryoides*, perhaps in *S. akenioides* also. In the former the pollen appears to have undergone a process of dehiscence or fragmentation about this time, whilst in *S. akenioides* it became perforated. Ultimately the pollen-fragments of *Stephanospermum caryoides* were ruptured by the mother-cell reticula. From these, antherozoids escaped, leaving traces of the reticula behind. Bodies which might conceivably be the antherozoids have been observed in *S. caryoides* only. They occur associated with the pollen-fragments or on the floor of the pollen-chamber on the way to the archegonia.

Adequate supplies of moisture would be drawn from the tracheal sheath. If the mucilage began to dry up at any time, its greater concentration would lead to further supplies of water being absorbed from the tracheides. In the absence of pollen-tubes, fertilisation would depend on the pollen-chamber being nearly full of watery mucilage.

From the researches of Webber* we know that the pollen-chamber is dry, or, rather, saturated with vapour, not full of water, during the maturation of the antherozoids in recent Cycads. The same may have obtained in *Stephanospermum* during the earlier stages of development. As the antherozoids came to maturity, however, it would become necessary for the chamber to be filled, so that they might swim across the considerable interval. Meanwhile the pollen-chamber had been extending downward to the archegonia, and a quantity of damp mucilage would thus be always present. Finally, the tracheal sheath which overlies the prothallium itself underwent a breakdown, probably of the same kind, and disappeared from this region by fertilisation-time (*cf.* p. 369). This would explain the differences in fissibility in this region between younger and "normal" stages in *S. akenioides* noted at p. 370. In the younger seeds the tracheides formed a compact sheath, and the splitting in post-mortem contraction of the macrospore occurred in the least resistant plane, which was below the tracheides (see p. 370 and Pl. 42. fig. 13); in the older ones, which seem to have been preserved just prior to fertilisation, the tracheides below the chamber were already weakened, and so the split leading to the production of the supra-archegonial gap occurred in the tracheal layer itself (Pl. 42. figs. 8 & 12). Further, in *S. caryoides*, where the evidence points to ours being the actual fertilisation-stage, tracheides are wholly wanting from the floor of the pollen-chamber, though they begin just where the corner below the shoulder is turned. It may be conjectured they have disappeared from this region. By realising that the tracheides degenerated in this way as fertilisation-time approached two minor facts of observation are rendered intelligible: (1) the relative fissibility of different layers according to the age of the seed; (2) the almost total absence of tracheides from the supra-archegonial gap in *S. caryoides*. That the breakdown of the tracheides in this region should have impeded the outflow of water is hardly to be supposed. That the top of the macrospore should remain littered with tracheides and partly unrolled spirals is hardly consistent with zoidiogamy. Such entanglements would impede the movements of the antherozoids. The inferred degeneration of the tracheides, however, solves the difficulty. The view here stated, though somewhat hypothetical in character, rests in a measure on the observed facts.

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* H. J. Webber, 'Spermatogenesis and Fecundation of *Zamia*,' 1901.

It will be appropriate to consider here very briefly the fertilisation-mechanism of recent Cycads. In *Zamia* the archegonia open upon a shallow depression termed the archegonial chamber. The pollen-tubes hang down, so that their ends approximately touch the necks of the archegonia. As yet the chambers (the pollen- and archegonial chambers) are dry or merely moist. The pollen-tubes burst and the antherozoids are discharged together with the fluid that distends the pollen-tubes—a mechanism recalling that of the stinging-hair of a nettle. The necessary fluid for the antherozoids is therefore supplied from the pollen-tubes just before fertilisation. This mechanism is a special one correlated with the reduction in number of antherozoids produced by each pollen-grain, and marks a high degree of precision and certainty in bringing the antherozoids to the archegonia, indeed it is the perfection of attainable accuracy possible with free-swimming antherozoids.

In *Stephanospermum caryoides* the arrangement was more primitive. The antherozoids were liberated from the pollen-grains at a distance from the archegonia relatively remote. Correlated with the distance to be traversed by the antherozoids we note their production in larger numbers than in recent Cycads [*]. Whilst in the latter two are formed from each pollen-grain, in *S. caryoides*—assuming two internal cells to each pollen-grain and that each of them produces a packet of four or five antherozoid mother-cells—the minimum number of antherozoids per pollen-grain may safely be estimated at eight. In the pollen-chamber of our seed (not counting pollen-grains lost in the cutting and grinding of the sections) there are ten internal cells accounted for (see text-fig. 2, p. 380)—*i. e.*, ten packets of, say, four antherozoids each. This gives a minimum of forty antherozoids [†], a number that would necessitate pollination in the Cycad by at least twenty pollen-grains.

The supposed antherozoids of *S. caryoides* are small, having average dimensions of $17\,\mu \times 15\,\mu$. These dimensions are confirmed by those of the individual cells of the secondary reticula. Those of Cycads are large and in some cases immense. They range from $82\,\mu \times 49\,\mu$ in *Ginkgo*, $160\,\mu \times 70\,\mu$ in *Cycas*, to 222–$322\,\mu \times 222$–$306\,\mu$ in *Zamia*.

Whether *S. caryoides* belongs to a stock from which recent Cycads have originated, or whether, as seems probable, the series are distinct, they stand on quite different planes of remoteness from Pteridophytes. In the Cycads we have a highly specialised pollen-tube-antherozoid-mechanism with reduction in number and increase in size of the antherozoids. In *S. caryoides,* so far as the antherozoids are concerned, we have a type relatively near the Pteridophytes—a condition analogous to that which might obtain if, in such a type as *Selaginella*, a pollen-chamber and integument be superadded to the macrosporangium, and the microspores being introduced into this chamber followed their normal development. The antherozoids (if such they be) have dimensions comparable to those of Pteridophytes rather than those of Cycads, whilst all the facts observed are consistent with their liberation at a considerable distance from the archegonia.

[*] A point anticipated on general grounds by D. H. Scott, 'Studies in Fossil Botany,' p. 435.

[†] In *S. akenioides*, assuming one antherozoid to arise from each of the (say) twenty cells in a pollen-grain, we have in Pl. **41.** fig. 3 seven non-abortive grains, *i. e.* one hundred and forty potential antherozoids.

Comparison with other Palæozoic Seeds.

Just as among recent plants, where all seeds seem much on the same plane and the pollen-tube is the dominant mechanism of fertilisation, though in archaic forms like the Cycads we get the end of the zoidiogamic epoch, so in Palæzoic times—or, more precisely, in the later periods of the Permo-carboniferous—fertilisation-mechanisms would seem to be also much on a plane. We have in the remarkable constellation of seeds from Grand' Croix a fair sample of seeds probably in the zenith of their zoidiogamic phase of evolution. That amongst them the beginnings of siphonogamy may here occur is possible, so that if Renault's surmise of a specialised operculum in *Ætheotesta* * prove correct, there would be distinct indications of a foreshadowing of a pollen-tube. That the Grand' Croix seeds were without pollen-tubes, as we understand them, seems more probable, in view of the statement of so careful and indefatigable an investigator as Renault, who tells us in more than one passage (prior to the year 1901) that of the 300 odd seeds that have passed through his hands this structure has never come under his observation.

It seems worth while to contrast *Stephanospermum* with the associated genera of seeds with a view to ascertaining in how far they present resemblances or differences in their general organisation, and to what extent they may be arranged under provisional groups.

Brongniart and, since his time, all botanists who have touched the subject distinguish between the seeds of this period possessing a bilateral symmetry and those which, on the other hand, are radially symmetrical.

The bilateral forms, which for convenient reference may be termed the PLATYSPERMEÆ, include the types known as *Cardiocarpus*, *Rhabdocarpus*, *Diplotesta*, *Sarcotaxus*, *Leptocaryon*, *Taxospermum*, and *Cycadinocarpus*. Of these, many are probably Cordaitean in their affinity, whilst *Cycadinocarpus* may perhaps, as Renault supposes, approach the Cycads. They belong to one phase of evolution, and have in common more especially the complex chalazal plate from which the bundles both of testa and nucellus-wall take origin, the small pollen-chamber, and flattening more or less considerable.

Brongniart's other series, which we may term the RADIOSPERMEÆ, include several groups based on the form of the transverse section :—

(1) *Stephanospermum, Ætheotesta, Gnetopsis*	Circular.
(2) *Trigonocarpus, Tripterospermum, Pachytesta*	3-ridged.
(3) *Eriotesta, Codonospermum*	Octagonal.
(4) *Polylophospermum, Polypterospermum, Hexaspermum, Ptychospermum.*	Hexagonal.

Of these many are much complicated by the presence of ridges and other emergences from the testa. These peculiar specialised forms may be left on one side for the present, but attention may be usefully directed to the members of groups (1) and (2).

Ætheotesta evidently, as a seed, very nearly resembles *Stephanospermum.* Two species have been described—*Æ. subglobosa*, Brongn., *Æ. elliptica*, B. Renault.

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* Renault, "Sur quelques pollens fossiles," Soc. d'Hist. nat. d'Autun : extr. du Procès-verbal de la Séance du 13 juin, 1901.

Ætheotesta subglobosa, Brongn., is very imperfectly known. It is a globular seed, having a transv. diam. 12–15 mm. Brongniart sketches the general macroscopic characters of very imperfect specimens in figs. 16, 17, 18, pl. C., in his 'Graines fossiles.' The micropyle is not shown, but the apical end of the seed was flattened and hairy, though there does not seem to have been the shallow, trough-like depression that we get in *S. caryoides*. The basal end of the seed was peculiar, owing to the presence of an aril-like cushion around the point of insertion. The nucellus was much retracted and possessed a roomy pollen-chamber. Though differing in details, in its general characters this seed was not unlike *S. caryoides*. How near the resemblance goes can only be determined when the original specimens are compared *.

Æ. elliptica, B. Renault.—Of this seed Renault gives considerable details †. Though larger and relatively longer than *S. caryoides* it possesses the same broad type of pollen-chamber as that seed. The vascular supply of the nucellus, which is derived in the usual way from the chalazal bundle, is not a continuous mantle but consists of distinct strands. The pollen is interesting as the very large grains ($320–400\,\mu \times 270–310\,\mu$) are identified by Renault as being the spores of *Dolerophyllum* which have lost their extine. This author holds the view that the pollen of *Dolerophyllum* underwent dehiscence prior to pollination, and that the inner cell-complex alone penetrated to the pollen-chamber. The pollen-grains, except for their larger size, resemble those of *S. akenioides* and like these became profusely perforated.

There was an outer fleshy (?) coat with chief development at the two ends of the seed. At the micropylar end this layer was much chambered, an arrangement which Renault interprets as a floating mechanism. Though apparently very similar to *Stephanospermum*, this seed, apart from the lacunate sarcotesta, differs in the grouping of the nucellar tracheides into bundles.

Gnetopsis elliptica, R. Zeiller.—These are tiny seeds (2·5 mm. × 1·2 mm.) bearing feathery arms at the micropyle like the nut of an *Abelia*. They have been found by Renault surrounded to the number of 3 and 4 by a two-membered cupule ‡. The tracheal elements appear to be concentrated in four bundles, but whether they really belong to the nucellus seems open to question. The presence of the enclosing cupule here is an interesting fact, as it is the only instance as yet amongst the Radiosperms in which evidence has been obtained as to the kind of structure to which these seeds were attached. It does not appear, however, that the cupule exhibits any characteristic feature sufficient to warrant a reference to the plant upon which it was borne.

So far, then, as this group is concerned, we have smooth seeds, circular in transverse section, one with a definite sarcotesta (*Ætheotesta*), all with adaptations of one sort or another at the micropylar extremity. The *Stephanosperma* alone show a continuous tracheal mantle in the nucellus in contradistinction to discrete bundles in the other forms. In none of the forms other than the two seeds here described has any observation been put on record as to a layer internal to the sclerotesta. But perhaps special attention has not been directed to this point.

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* In the contingency of *Stephanospermum caryoides* eventually being recognised as identical with *Ætheotesta subglobosa*, Brongn., the discrepancy in respect of the pollen would still remain, as the pollen-grains of *Ætheotesta elliptica*, B. Renault, are stated to be of the *S. akenioides* type.

† 'Flore fossile d'Autun, &c.' pp. 272–278.

‡ 'Cours,' iv. pl. 20.

The second group of the Radiospermeæ, which includes *Trigonocarpus*, *Tripterospermum*, and *Pachytesta*, is an interesting one demanding some consideration.

Tripterospermum, Brongn., seems to be as unspecialised a seed as any from the Palæozoic rocks. It is an oval seed with a beak-like micropyle and possessed a sarcotesta external to the sclerotesta. Longitudinally, there run three symmetrically placed ridges; ultimately dehiscence probably occurred along these lines. To this genus the Trigonocarpons from the Lancashire Coalfield described by Sir J. D. Hooker and Binney[*] probably belonged, as Brongniart has suggested[†].

The seed described by Williamson[‡] under the name of *Trigonocarpon olivæforme*, though slightly larger than the Hooker and Binney specimens, unquestionably belongs to the same affinity. Consequently, for the purposes of the present discussion, both these Trigonocarpons may conveniently rest in the Brongniartian genus *Tripterospermum*[§].

Particular attention was drawn to the Hooker and Binney specimens from a study of pl. 4. figs. 5, 9, and 10 of their Memoir. Here is shown a circular ridge surrounding the base of the micropylar beak which recalls the crown of a *Stephanospermum*. On consulting the original specimens[||] I find that this apparent ridge is in reality due to a corrosion or decomposition of the tissue in this region, so that the marked resemblance is illusory. The only other point about these seeds calling for mention is that the tracheal elements ensheathing the nucellus are well preserved, though it is difficult to decide whether they formed a continuous mantle or separate bundles. The pollen-chamber is smaller relatively than in *Stephanospermum*.

Pachytesta[¶] was the largest of the Palæozoic seeds, approaching a hen's egg in dimensions as in form. The testa was massive and complicated, whilst the chalaza was remarkable in the presence of a conspicuous peduncle upon which the nucellus stood. Apart from the complexity of the testa, which possessed an extensive endotesta, this seed is characterized in that the nucellus appears to have borne longitudinal ridges which engaged with corresponding grooves in the endotesta. In view of these and other peculiarities, *Pachytesta* may perhaps be detached from the near alliance with *Trigonocarpus* and *Tripterospermum* implied in Brongniart's grouping of the genera.

Trigonocarpus, Brongn., may be provisionally placed in this section. *T. pusillus* was the smallest of the seeds described by Brongniart [*]. It is three-ridged, but appears to resemble *Tripterospermum* (with which, no doubt, it was closely allied) in the possession of a sarcotesta, of which traces are present.

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[*] "On the Structure of certain Limestone Nodules, &c.," Phil. Trans. vol. 145 (1855), p. 149.

[†] 'Graines fossiles silicifiées,' p. 26, footnote.

[‡] "On the Organisation of the Fossil Plants of the Coal-Measures: Part VIII.," Phil. Trans. 1877, p. 248.

[§] I am in agreement with Williamson (*loc. cit.* p. 253) that a redundancy of genera has been created for the known Radiosperms.

[||] It is owing to the kindness of Sir Joseph Hooker that I have been able to trace the originals to the Geological Department of the Natural History Museum. Here are to be found the specimens (all longitudinal sections) upon which are based figs. 6, 7, 8, and 9, pl. 4, of the Hooker and Binney Memoir. Sir Joseph Hooker's figures are drawn in natural size and are practically facsimile representations of the specimens.

[¶] For full description see Brongniart, *loc. cit.* p. 25, pl. B. figs. 4 & 5, and pls. 18–21; also Renault, 'Flore fossile d'Autun et d'Épinac,' p. 389, and pls. 83 & 84. figs. 1 & 2.

Of the remaining genera of Radiosperms, the seed *Polylophospermum*, Brongn. [†], may be cited as possessing, in essentials, a *Stephanospermum*-organisation, *i. e.* a vascular nucellus and a large broad pollen-chamber in conjunction with radial symmetry. The testa is complicated by chalazal and micropylar expansions, in addition to longitudinal ridges, whilst an outer fibrous or succulent "sarcotesta" enveloped the stone of the seed.

Beside this seed, *Codonospermum*, Brongn. [‡], naturally takes its place. As Renault has shown [§], this seed also possessed a sarcotesta.

In addition to the above, the ridged seeds *Colpospermum*, B. Renault [||], *Ptychotesta*, Brongn. [¶], *Polypterospermum*, Brongn.[**], and *Hexapterospermum*, Brongn. [††], and perhaps others, may be included as possessing the same general organisation as *Stephanospermum*, and as being marked out for retention in the same group.

To summarize the remarks, it may therefore be suggested that the following genera of Palæozoic seeds, having a like organisation, possess a bond of real affinity:—*Stephanospermum*, *Ætheotesta*, *Trigonocarpus*, *Tripterospermum*, and the Trigonocarpons of Hooker & Binney and Williamson [‡‡], *Polylophospermum*, *Codonospermum*, *Colpospermum*, *Ptychospermum*, *Polypterospermum*, and *Hexaspermum*. It is these forms, at present largely recruited from the French Permo-Carboniferous, that constitute the *Stephanospermum*-group of the Radiosperms.

The main features of this group are: radial symmetry; a nucellus traversed peripherally by a mantle, network, or distinct strands of tracheal elements; a relatively broad pollen-chamber; a stony testa with a tendency to be produced into transverse or longitudinal ridges, &c.; an outer fleshy or fibrous sarcotesta.

In the case of the type-genus, *Stephanospermum*, apart from the apex of the seed, evidence for the existence of the sarcotesta is lacking; but when the structure of this seed is considered as a whole (*cf.* p. 363), we can hardly avoid the conclusion that it resembled its contemporaries in this feature also.

During the passage of the present paper through the press, strong evidence has been adduced for referring the English Lower Coal-Measure seed, *Lagenostoma Lomaxi*, to the well-known fossil plant *Lyginodendron oldhamium* [§§]. Now this seed, and the other Lagenostomas of Williamson [*], have a peculiar organisation that differentiates them from *Stephanospermum* and its allies, though they resemble the latter in their radial symmetry. Perhaps the most important feature of difference is the vascular system of the seed, which is *nucellar* in *Stephanospermum* but wholly *integumental* in *Lagenostoma*. When regard is had to the Cycadean character of the seed *Lagenostoma*, on the one hand, and of the vegetative organs known as *Lyginodendron*, the plant to which it belonged, on the other, little doubt can remain as to the close relations that must have existed between this plant and the ancestors of existing Cycads.

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[*] Brongniart, 'Graines fossiles silicifiées,' p. 24.

[†] Brongniart, *loc. cit.* pl. C. figs. 6, 7, 8.

[‡] Brongniart, *loc. cit.* pl. C. figs. 10, 11, 12; also Renault, 'Flore fossile d'Autun et d'Épinac, p. 393, and pl. 87.

[§] Renault, *loc. cit.* p. 394.

[||] Renault, *loc. cit.* p. 400.

[¶] Brongniart, *loc. cit.* pl. B. figs. 10, 11; also Renault, *loc. cit.* p. 401.

[**] Brongniart, *loc. cit.* pl. C. figs. 1, 2, 3.

[††] Brongniart, *loc. cit.* pl. B. figs. 12, 13, 14.

[‡‡] When the time arrives for a revision of these genera of seeds, the name *Trigonocarpus* may be appropriately associated with the Hooker and Binney specimens on the ground that the description of these *petrified* specimens holds unquestioned priority in the field of investigation of seeds with structure preserved.

[§§] Oliver, F. W., and D. H. Scott, "On *Lagenostoma Lomaxi*, the Seed of *Lyginodendron*," Proc. Roy. Soc. vol. lxxi. (1904) p. 477.

In addition to the Lagenostomas, possibly other seeds from the English Carboniferous rocks may be referred eventually to this group of seed-bearing Fern-like plants (the Lyginodendreæ). The seed *Gnetopsis*, Renault, also may possibly belong to the same cycle of affinity—in any case it presents close agreement with *Lagenostoma* in several ways [†].

The affinities of the *Stephanospermum*-group of seeds, however, are not yet known with certainty, though there are reasons for supposing that one of its members, the English *Trigonocarpon olivæforme*, may have belonged to the genus *Medullosa* [‡]. Further, there is Mr. Kidston's recent discovery of a seed, not wholly unlike a member of this group, in connection with the pinnules of *Neuropteris heterophylla*, a fern-frond also referable to the Medulloseæ [§].

Hence the position in respect of the radially organised seeds is as follows:—The *Lagenostoma*-group have been definitely referred to *Lyginodendron*, and take their place as the seeds of forms intermediate between true Ferns and Cycads. The rich series of seeds that conform to the *Stephanospermum*-type, on the other hand, are not yet so definitely referred, but it is a reasonable anticipation to suppose that they will eventually—through the Trigonocarpons—find a place in the Medulloseæ.

It may perhaps be added that remains of *Alethopteris* pinnules and of *Myeloxylon* petioles are exceedingly abundant in the pebbles in which *Stephanospermum* occurs; but that, whilst the association of the last-named with the two former is very close and constant, no evidence of actual continuity has been discovered during the course of the present investigation.

The other French seeds described by Brongniart [||], *Cardiocarpus*, *Rhabdocarpus*, and similar forms, are by common consent attributed to the Cordaiteæ. As the organisation of these "Platysperms" is very uniform, and actual continuity with Cordaitean tissues has been established by Renault in certain instances [¶], we may regard the position of these seeds as definitely settled. The resemblances which they present with the seeds of recent Cycads have been pointed out by various writers and are quite evident. Nevertheless, in view of the close Cycadean affinity offered by the *Lagenostoma-Lyginodendron* Cycadofilices in respect of reproductive and vegetative organs alike, it seems quite probable that the Cordaiteæ and Cycadaceæ are less nearly related than has often been supposed. The former are an ancient group and retain relatively little of their Filicinean ancestry. The likeness in seed-structure may perhaps be regarded as a parallel development in related, but not very closely allied, lines of descent.

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[*] Williamson, "Organisation of the Fossil Plants of the Coal-Measures: Pt. VIII.," Phil. Trans. vol. 97, p. 233.

[†] See a forthcoming memoir in conjunction with D. H. Scott, F.R.S., "On the Structure of *Lagenostoma Lomaxi*, &c."

[‡] G. Wild, "On *Trigonocarpon olivæforme*," Trans. Manchester Geol. Soc. vol. xxvi. 1900; D. H. Scott, "On the Origin of Seed-bearing Plants," Lecture delivered before Royal Institution of Great Britain, May 15, 1903, p. 11.

[§] R. Kidston, F.R.S., "On the Fructification of *Neuropteris heterophylla*, Brongn.," Proc. Roy. Soc. vol. lxxii. (1904). p. 487.

[||] *Loc. cit.*

[¶] 'Flore carbonifère,' p. 311.

In the same way the agreement in details of seed-structure in Cycads on the one hand, and in *Stephanospermum* and similar forms on the other, should not be too closely pressed. For, in view of the position of *Lagenostoma*, the relation of *Stephanospermum* to *Cycas* is more remote than may have appeared to be the case before the sorting-out process began. For, if the Cycadean seed be interpreted in terms of *Lagenostoma*, as it needs must be, it is difficult to resist the conclusion that the inner system of vascular bundles in the former is, in reality, integumental in character rather than nucellar. Consequently, the homology of this system of strands with the vascular mantle of a *Stephanospermum*, an homology implied by the present writer on a former occasion *, stands in need of revision.

SUMMARY AND CONCLUSION.

In whatever respects the seeds of Palæozoic age may have differed among themselves, as in the structure of the integument and in the position of the vascular system, they all show marked agreement, as originally pointed out by Renault †, in the possession of a pollen-chamber. This applies to both provisional groups of the Radiospermic series (Lyginodendreæ and Stephanospermeæ) as also to the Platysperms (Cordaiteæ). And in this respect they contrast in marked degree with recent plants, always excepting such archaic Gymnosperms as are fertilised by spermatozoids. The pollen-chamber was evidently an adaptation of the distal portion of the macrosporangium, connected with the reception and storing of the microspores and the liberation of spermatozoids. Indeed, it is difficult to conceive any essentially different method by which a seed could have been evolved, assuming always, of course, that fertilisation by spermatozoids was retained. And it would be improbable in the highest degree that the particular conjunction of factors that led to the production of a pollen-tube should have operated contemporaneously with those others which produced the pollen-chamber.

The old type of seed was of necessity, then, a complicated structure, as the microspores had to be collected and nursed, and provision made for the swimming of the spermatozoids. The pollen-chamber seems to have reached its zenith in Permo-Carboniferous times, and its decline was doubtless correlated with the evolution of pollen-tubes. The result we see in recent Conifers, with their simple reduced nucelli and siphonogamic methods.

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* *Cf.* 'Annals of Botany,' vol. xvii. p. 466.

† 'Flore carbonifère,' p. 310.

Very few instances of early seed-like structures without pollen-chambers are at present known. *Lepidocarpon* alone has been at all fully described *; but even here nothing has been ascertained in regard to either pollination or fertilisation. In view of this paucity of data, a comparison of the two seed-types is hardly possible. It may be observed, however, with some confidence, that the *Lepidocarpon*-type has left no seed-bearing progeny, whilst there is at least equal probability for the assertion that the whole of existing Gymnosperms have originated from an ancestral type characterised by the possession of a pollen-chamber.

One reason for the predominance of the pollen-chamber may reside in the water-relations. The Pteridophytic alternation of generations, though a step in advance of the Algal condition, was not the ideal state for a dry-land flora. The early seed-habit, in its initiation, perhaps, largely a xerophilous adaptation, contained the germ of much else beside. The water-relations in question are very evident in the seeds of the *Stephanospermum*-type, where the ample sheath of transfusion-tracheides would provide such moisture as may have been required. But as yet the nutritive possibilities had not been realised in the way in which they are realised in recent plants. Already, before fertilisation, the seed seems to have reached maturity, and it is difficult to conceive how such a structure could have enlarged and accommodated rich supplies of food-material for the embryo. The real ovular stage was intercalated at a later date.

In point of fact our information as to the early developmental stages of Palæozoic seeds is exceedingly meagre. Renault has described young Cordaitean seeds, and these were already pollinated; but we know nothing as to the time of pollination in *Stephanospermum*. The mature seeds contain pollen; two slightly younger stages, one figured in the present paper (Pl. **42**. fig. 13), are without pollen; but these preparations are neither numerous nor favourable enough to justify any confident inference as to the time of pollination. Nor, on the other hand, can we assume that these seeds were pollinated, like *Cordaites*, whilst quite small; for the latter type is immensely old, and its seeds are not necessarily on quite the same plane of evolution as *Stephanospermum*.

If it be recognised that the nearest affinities of recent Cycads lie with the *Lyginodendron*-branch of the Cycadofilices rather than with the Stephanospermeæ, it almost follows that the latter have died out and are unrepresented in the existing flora. The apparent perfection of the vascular mantle in *Stephanospermum* may have proved an obstacle to further development. And if this type of seed should be shown to have belonged to a *Medullosa*-type of stem, have we not in their conjunction an over-elaborated organisation marked out for subsequent decline?

The phylogenetic history of so specialised a seed-type as *Stephanospermum* is extremely obscure. It may be conjectured that the pollen-chamber corresponds to some modification of sporangial dehiscence, whilst the tracheal mantle finds its analogue in an unassigned fossil sporangium with tracheal lining from the same horizon †. The morphological nature of the integument is no less obscure.

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* D. H. Scott, "The Seed-like Fructification of *Lepidocarpon* &c.," Phil. Trans. series B, vol. 194, p. 291.

† "A Vascular Sporangium," New Phytologist, vol. i. 1902, p. 60.—A type of sporangium that may be termed conveniently *Tracheotheca*.

In conclusion, I would express my obligations to Dr. Smith Woodward, F.R.S., to whom I am indebted for access to the Williamson and other collections in the Geological Department of the Natural History Museum, and for facilities in preparing sections of some of the seeds in his custody; to Mrs. A. G. Tansley, who has rendered great assistance in preparing sections of recent plants for purposes of comparison; and to Dr. D. H. Scott, F.R.S., who has given me much encouragement in the course of this investigation. My thanks are also due to Mr. A. K. Coomáraswámy and to Mr. W. Tams for the photographs which accompany this paper.

[The opportunity afforded by the passage of this paper through the press has been utilised to revise certain portions in correspondence with the facts that have accrued since it was written.—F. W. O., *February* 1904.]

EXPLANATION OF THE PLATES.

Figures 1–16, *Stephanospermum akenioides*; 17–20, *Stephanospermum caryoides*: all taken direct from the sections. Almost all should be examined with the aid of a lens. Figures 1–16 are from photographs by Mr. W. Tams, of Cambridge; 17–20 by Mr. A. K. Coomáraswámy, B.Sc., F.L.S. Figures 29, 38, 41, and 43 are from drawings by Mr. G. T. Gwilliam.

PLATE 41.

Stephanospermum akenioides, Brongniart.

Figs. 1, A & B. Median longitudinal section of apex and base. A narrow zone from the middle part of the seed alone is unrepresented in the two figures. The most noteworthy feature here shown is the relation of the collar to micropyle and nucellar apex. Shown on a large scale in Pl. **43**. fig. 29. *c.*, crown; *co.*, collar; *end.t.*, remains of endotesta; *n.e.*, epidermis of nucellus; *pa.*, basal papilla; *p.c.*, pollen-chamber, much macerated; *t.d.*, tracheal disc at the chalaza; *v.b.*, the entering vascular bundle. ×15. S 6 A *. (See pp. 363, 365.)

Fig. 2. Median longitudinal section of micropyle and pollen-chamber. In the latter is a cluster of pollen-grains excellently preserved. Figs. 14 and 16 show the pollen under higher magnification, as also do figs. 30, 31, and 35. *co.*, collar, cut a little tangentially; *h.*, remains of hairs which lined the perimicropylar trough; *m.w.*, wall of macrospore; *s.* is level with the remains of septum between the pollen-chamber and the supra-archegonial gap (*s.a.g.*); *sh.*, shoulder (*i. e.*, tissue of nucellus forming side of pollen-chamber). A more highly magnified view of a portion of the shoulder is given in fig. 11. × 15. S 7 A. (See p. 369.)

Fig. 3. Median longitudinal section through pollen-chamber with pollen. Most of the grains are congregated near the apex of the chamber, a few ($p.^1$) with the small abortive grains adjacent to it and the abortive grain ($p.^2$) have been drawn down, previous to mineralisation,

to the level of the septum or diaphragm (*d.*) or even lower into the supra-archegonial gap. *pr.*, prothallium with a well-marked archegonium (*ar.*); *p.g.*, an abortive pollen-grain trapped in the nucellar canal; *co.*, the collar (*cf.* fig. 1 A), a persistent detached portion of the epidermis; *cc*, ill-preserved remains of displaced endotesta; *e.*, epidermis of nucellus. ×30. S 2. (See p. 371.)

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* The reference letter and number refer to the slides upon which the photographs or drawings are based. Where not specially indicated, the slides are in the University College collection.

Fig. 4. Transverse section of the sclerotesta. *p.*, the palisade-layer showing the filamentous and often spiral contents with lenticular enlargements at places (*cf.* Pl. **43**. figs. 22, 23, & 24); *f.*, longitudinally running fibrous layer; *et.*, epithelioid lining of the sclerotesta; *n.e.*, ill-preserved epidermis of the nucellus. The intermediate endotesta between *et.* and *n.e.* not shown. ×145. S 17 C. (See p. 364.)

Fig. 5. A somewhat tangential longitudinal section of the apex of a seed. Wall of pollen-chamber and sclerotesta badly preserved. Supra-archegonial gap and septum well shown. The strands within the crown (*h.*) are excellently shown. ×17. S 1 A. (See p. 365.)

Fig. 6. Median longitudinal section through the micropyle. *et.*, epithelioid lining of sclerotesta. The nucellar beak is not preserved, but two fragments of the collar are preserved to right of apex of nucellus. Within the pollen-chamber, three large normal pollen-grains and one abortive. The grain *p.* is much enlarged in Pl. **44**. figs. 32, 33, & 34. ×14. S 8 A. (See p. 371.)

Fig. 7. Median longitudinal section through the base of the seed represented in fig. 6. The entering bundle and tracheal disc are well shown, as are the general relations of the parts at the base of the seed. *a*, point at which the macrospore has separated from the wall of nucellus. The chalaza is represented in detail in Pl. **43**. fig. 21. ×15. S 8 B. (See p. 367.)

Fig. 9. Tangential section through corner of supra-archegonial gap, showing the tracheides passing into the space. The section follows the plane running obliquely down from *a* in fig. 10. A group of these tracheides is drawn much enlarged in Pl. **43**. fig. 28. *m.w.*, macrospore-wall; *ep.*, epidermis of nucellus. ×80. S 9 C. (See p. 369.)

PLATE 42.

Fig. 8. Left-hand corner supra-archegonial gap—from the same specimen as fig. 10, but with the angle here directed upwards. Shows the tracheal sheath (*tr.*) splitting into an upper layer ($tr.^1$) lining the side of the gap, and a lower layer ($tr.^2$) resting on the macrospore-wall (*m.w.*). *n.e.*, epidermis of nucellus. ×155. S 12. (See p. 369.)

Fig. 10. Tangential section through apex of seed. Shows strands on the summit. The epithelioid lining of the sclerotesta is admirably preserved. Of the pollen-chamber only the flanking tissue (shoulder) is shown. The supra-archegonial space is conspicuous. *a* to left-hand bottom corner, plane of section from which fig. 9 was taken. ×14. S 12. (See p. 369.)

Fig. 11. Longitudinal section of lower portions of shoulder from same section as fig. 2. *sh.*, tissue of shoulder; *p.c.*, corner of pollen-chamber; *s.*, septum (*i.e.*, remains of floor of pollen-chamber); *s.a.g.*, supra-archegonial gap; *tr.*, tracheides attached to the septum, also drawn-out spirals lying free in the gap. ×105. S 7 A. (See p. 369.)

Fig. 12. Longitudinal section very similar to fig. 10. The supra-archegonial gap has numerous drawn-out tracheides in the angle, admirably shown (*tr.*). ×30. S 7 B. (See p. 369.)

Fig. 13. Longitudinal section of apex of nucellus of a rather younger seed than those usually found. *end.t.*, endotesta; *s.t.*, sclerotesta; *p.c.*, the quite small pollen-chamber; *s.a.g.*, supra-archegonial gap—in this case developed by a splitting of the tissue immediately below the tracheal sheath, × × mark the region of splitting; *e.t.*, displaced cell belonging to the epithelial lining of sclerotesta; *tr.*, the tracheal zone; *ar.*, archegonium. × 30. S 3 A. (See p. 370.)

Fig. 14. Apex of pollen-chamber and group of pollen-grains represented in fig. 2. *p.*, grain with internal cells in surface view; *p.*[1], longitudinal oblique section of a grain showing "replum"; *p.*[2], transverse section of a grain showing internal walls—this grain is drawn in Pl. **43.** figs. 30 & 31; *p.*[3], grain in longitudinal section showing replum, drawn in Pl. **44.** fig. 35; *p.*[2] and *p.*[3] also shown enlarged in fig. 16; *co.*, collar. ×58. S 7 A. (See p. 376.)

Fig. 15. Apex of nucellus in longitudinal section. Resting on the apex is the collar (*co.*). In the pollen-chamber a large pollen-grain with internal cells showing and a papilla on its underside; three abortive foreign pollen-grains are also present. × 16. Williamson Collection 1486 *a*. (See p. 378.)

Fig. 16. The two right-hand pollen-grains of figs. 2 and 14, much enlarged. *p.*[2], in transverse section, showing the internal walls; *ex.*, exospore: this grain is represented in Pl. **43.** figs. 30 & 31. *p.*[3], in longitudinal section, showing replum within: this grain is represented in Pl. **44.** fig. 35. ×100. S 7 A. (See p. 376.)

Stephanospermum caryoides, n. sp.

Fig. 17. Almost median longitudinal section of the seed. The black sclerotesta is in contact with the matrix. The micropyle, funnel-shaped, is seen at the summit. The nucellus is remote from the sclerotesta, except at the base, the space being somewhat increased, but not very much, owing to the three fissures in the preparation. The pollen-chamber is very broad, with well-preserved shoulder-tissue at the sides. The large embryo-sac contains the prothallium in its upper half. On the left-hand side of the embryo-sac the double membrane has resulted from the epithelium of the sclerotesta having separated from the latter till it touches the nucellar wall just where this is fractured. At *f* the dark fragments represent a portion of the macrospore-wall and overlying tracheal sheath that have become detached from their position and carried into the embryo-sac. This happened prior to mineralisation. *a* indicates the apex of the nucellus. In the matrix to the left is a Cordaitean bud. × 3. S′ 1 A. (See p. 374.)

Fig. 18. Part of pollen-chamber and shoulder from the same specimen. Lying at the side of the pollen-chamber is an intact pollen-grain (*p.*[2]) and a pair of internal cells from another grain (*p.*[3]). *s.*, septum, *i. e.* lower limit of pollen-chamber, below which is the narrow supra-archegonial gap. On the right the macrospore is broken through (*cf.* fig. 17). × 20. S′ 1 A. (See p. 375.)

Fig. 19. A pair of tracheides from the tracheal mantle. Their average diameter is about 27 μ. × 165. S′ 1 A. (See p. 375.)

Fig. 20. Secondary cell-reticulum contained in the cell *b* of Pl. **44.** fig. 42. ×250. S′ 1 A. (See p. 381.)

PLATE 43.

Stephanospermum akenioides, Brongniart.

Fig. 21. Median longitudinal section through a portion of the base of the seed shown in fig. 7. The entering vascular bundle (*v.b.*), tracheal disc (*t.d.*), and tracheal mantle (*t.m.*) are found in continuity. The bundle is accompanied by a layer of parenchyma (*sh.*), which expands below the tracheal disc into the parenchymatous layer (*p*), which is continued as the crushed hypoderm of the nucellus. Below the parenchyma is a plate of sclerised cells with carbonaceous contents (*scl.*). Distally, this plate is attached to the angle of confluence of the

epithelioid lining of the sclerotesta (*e.t.*) and nucellar epidermis (*n.e.*). *s.t.*, sclerotesta; *l.p.*, long palisade-cells of this layer adjacent to the entering bundle; *m.w.*, retracted wall of macrospore. × 65. S 8 B. (See p. 365.)

Figs. 22, 23, and 24. Cells from the sclerotesta showing admirable "cytological" preservation. Fig. 22 represents the adjacent ends of two cells from one of the deeper-lying layers: the paired convergent processes on either side of the transverse wall resemble the protoplasmic processes occupying the pits; in the spindle-shaped enlargements nuclei are present. Fig. 23, one of the shorter cells from the second layer of the sclerotesta. Fig. 24, a palisade-cell with nuclear vesicle (*n.*) and spirally twisted protoplast. At the inner extremity are two pit-processes (*p.*); at the surface one of the broad conical vacuole-like structures (*v.*) so commonly found in this position. *Cf.* fig. 4. × 400. S 8 B. (See p. 365.)

Fig. 25. Tangential section through the palisade-layer of the sclerotesta. The middle lamella and thickening layers of the wall are shown, and in a few of the cells the thread-like protoplasts as dots in the cell-cavities. × 200. S 19 A. (See p. 365.)

Fig. 26. Tangential section through the epidermis of the nucellus, showing three cells with the characteristic carbonised contents. At the top of the figure the section traverses the tracheal mantle, portions of two of these elements being represented. × 240. S 9 C.

Fig. 27. Two of the short and rather irregular tracheides from the tracheal disc shown in fig. 21. × 550. S 8 B. (See p. 367.)

Fig. 28. A small portion of the tracheal mantle where the elements are somewhat isolated as they pass into the supra-archegonial gap. They are from the same specimen as fig. 9. × 285. S 9 C. (See p. 369.)

Fig. 29. Median longitudinal section of micropyle, collar, and apex of nucellus, showing these parts in greater detail than in fig. 1 A. *m.*, micropyle occupied by the nucellar beak, *b.*; *co.*, collar; *x*, *x*, the symmetrically placed regions on either side at which the preservation of the collar ceases; *p.c.*, upper part of pollen-chamber; *a.*, apex of residue of nucellus after detachment of funnel-like beak; *e.t.*, epithelioid lining sclerotesta. × 80. S 6 A. (See p. 371.)

Fig. 30. Pollen-grain cut in transverse section, showing internal walls (*a*–*e*) meeting at the centre of the section. *ex.*, exospore running obliquely towards the pole of the grain. The same pollen-grain is represented in fig. 16, $p.^2$ × 180. S 7 A. (See p. 376.)

Fig. 31. The same section drawn from a deeper optical plane. Lettering as in fig. 30.

PLATE 44.

Figs. 32, 33, and 34. Three views of one pollen-grain cut in almost longitudinal section. Figs. 32 and 34 represent the two surfaces of the section, fig. 33 an optical section midway between them. The cells of the grain have come apart at the centre, leaving a space (fig. 33, *c*) in which the remains of the axis of union of the membranes is obscurely seen (*n*). *w.*, perforations in the walls of the internal cells. The pollen-grain here illustrated is marked *p.* in fig. 6. × 250. S 8 A. (See p. 377.)

Fig. 35. Pollen-grain marked $p.^3$ in Pl. 42. figs. 14 & 16. *ex.*, exospore; *c.*, internal cells; *c.b.*, central body or remains of joined internal angles of the cells, at *b* still continuous with a radial wall. *d* indicates approximate plane of transv. section represented in fig. 16, $p.^2$, and figs. 30 & 31; *e*, *f*, approx. plane of section of pollen-grain, $p.^1$, fig. 14. × 235. S 7 A. (See p. 377.)

Stephanospermum caryoides, n. sp.

Fig. 36. Median longitudinal section of apex of seed, showing the micropyle (*m.*), perimicropylar area, and strands; *n*, summit of pollen-chamber. × 10. S′ 1 A. (See p. 373.)

Fig. 37. Portion of a hair or branching strand of cells from the perimicropylar area. × 330. S′ 1 C. (See p. 374.)

Fig. 38. Apex of nucellus with insertion of nucellar beak. *n.e.*, epidermis of nucellus; the pollen-chamber is below. A nearly horizontal fissure traverses two-thirds of the region drawn. × 65. S′ 1 B. (See p. 374.)

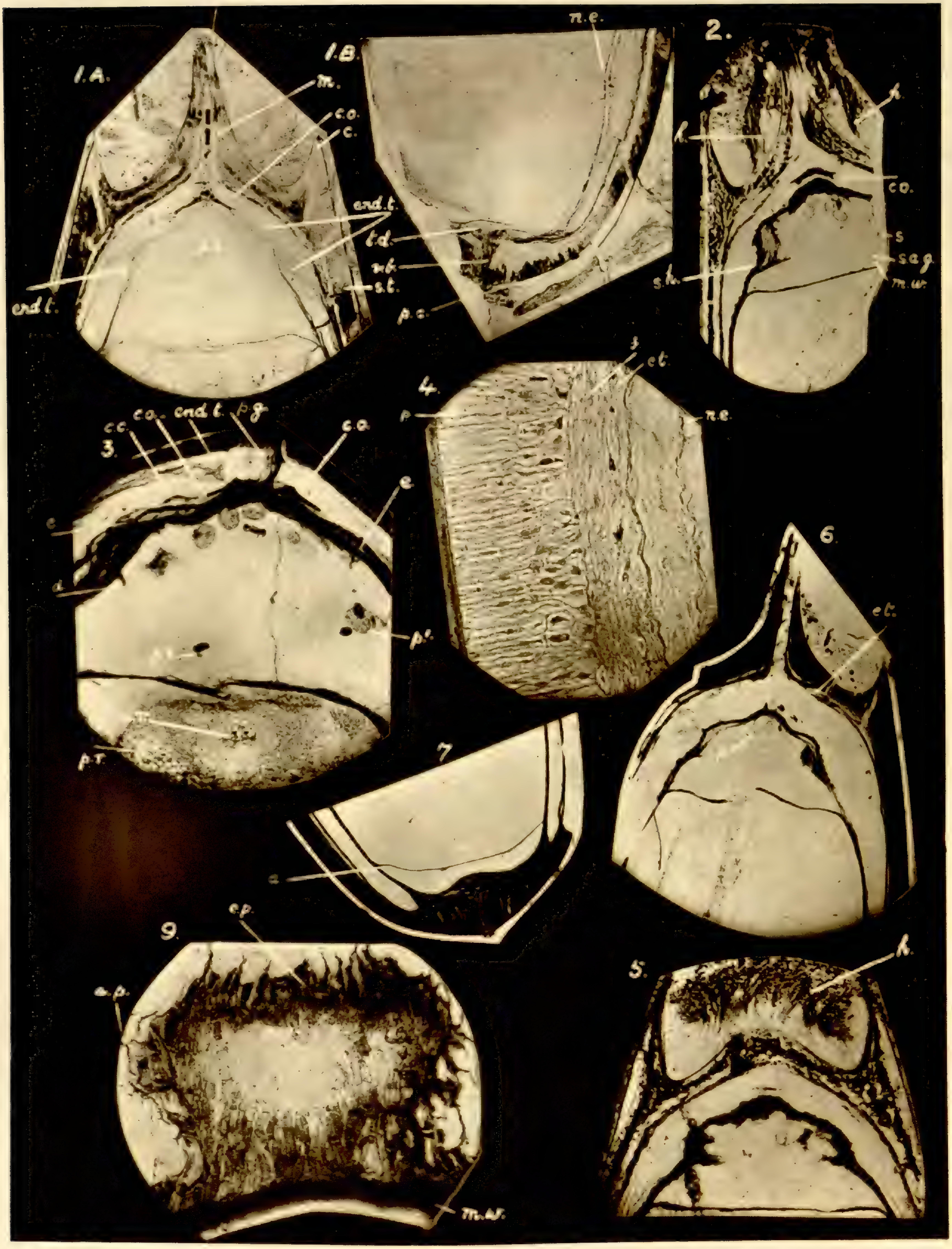
Fig. 39. Tracheides from the nucellar wall. × 370. S′ 1 B. (See p. 375.)

Fig. 40. Pollen-grain *p.* in text-fig. 2 (p. 380). *a* and *b*, internal cells; *c*, blister-like excrescence of outer wall; *tr.s.*, indication of triradiate mark on the grain. × 280. S′ 1 B. (See p. 380.)

Fig. 41. Pollen-grain fragment $p.^1$ in text-fig. 2. The cell contains a secondary reticulum of possible antherozoid mother-cells. *w*, exospore. × 650. S′ 1 A. (See p. 381.)

Fig. 42. Pollen-group $p.^2$, $p.^3$ from fig. 18. $p.^2$, intact pollen-grain showing the triradiate mark; $p.^3$, pollen-fragment of two internal cells, *a* and *b*, latter represented in fig. 20. × 310. S′ 1 A. (See p. 381.)

Fig. 43. Two conjectured antherozoids in the petrified mucilage on the floor of the pollen-chamber. × 465. S′ 1 A. (See p. 383.)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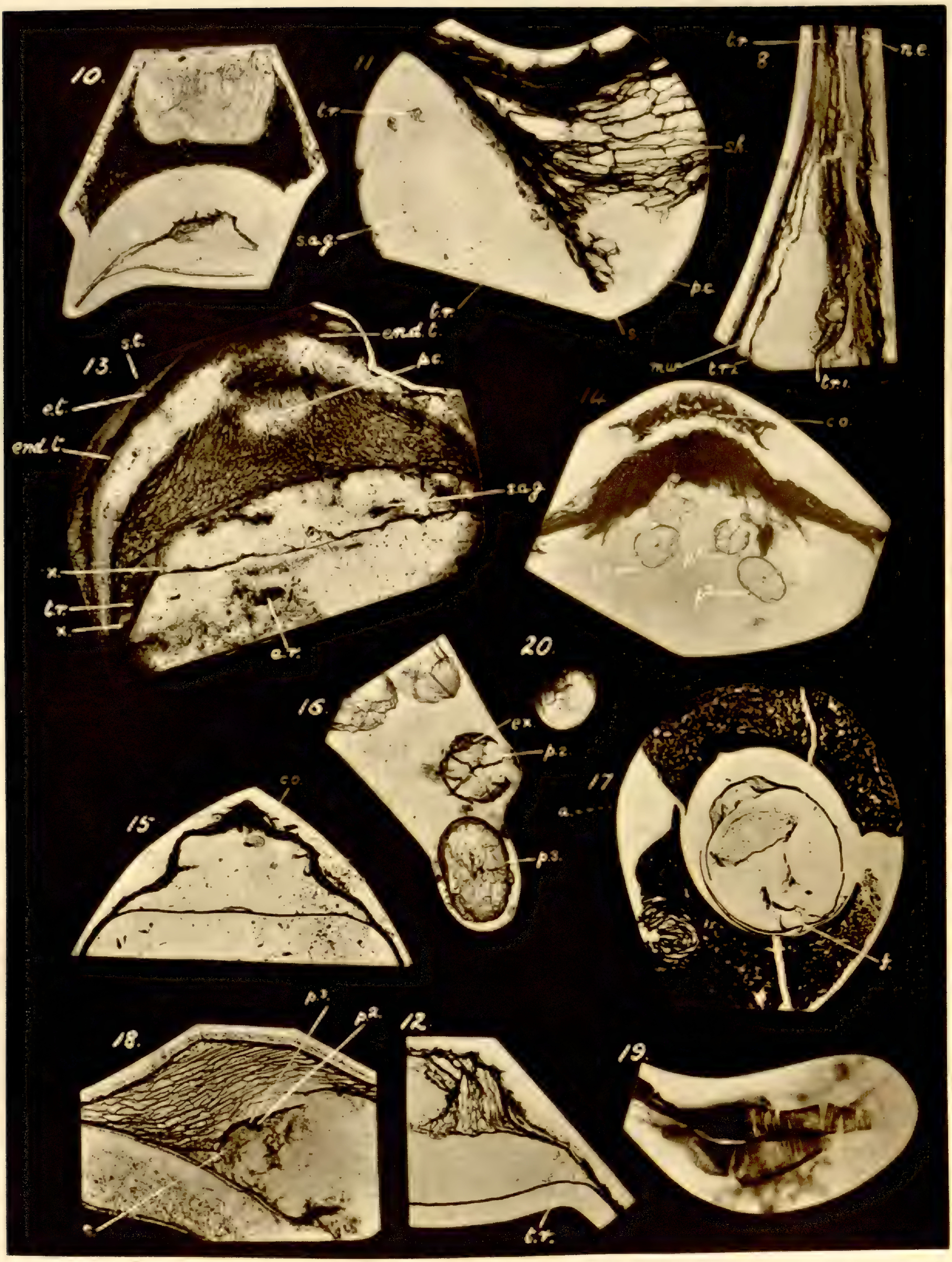
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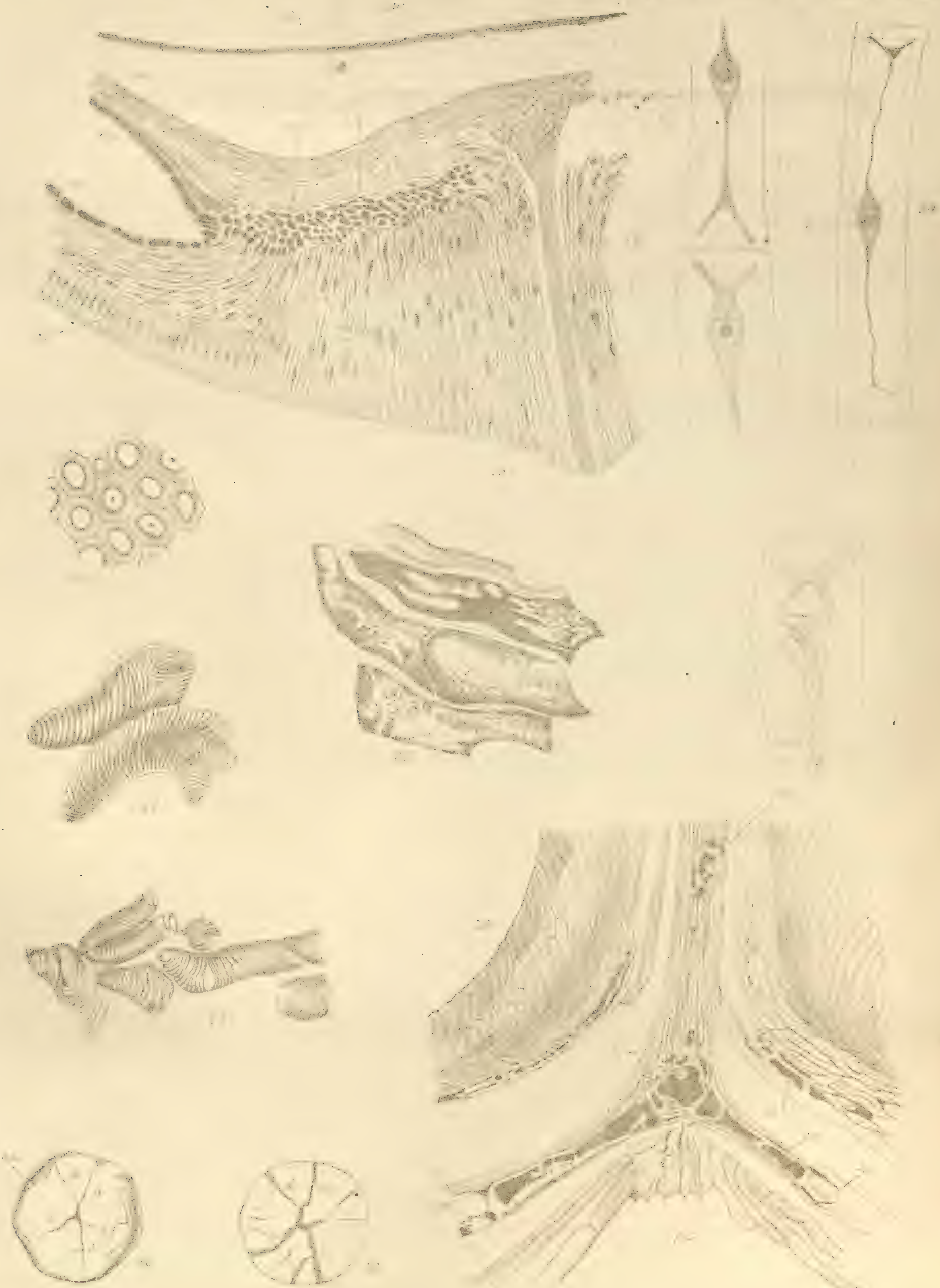

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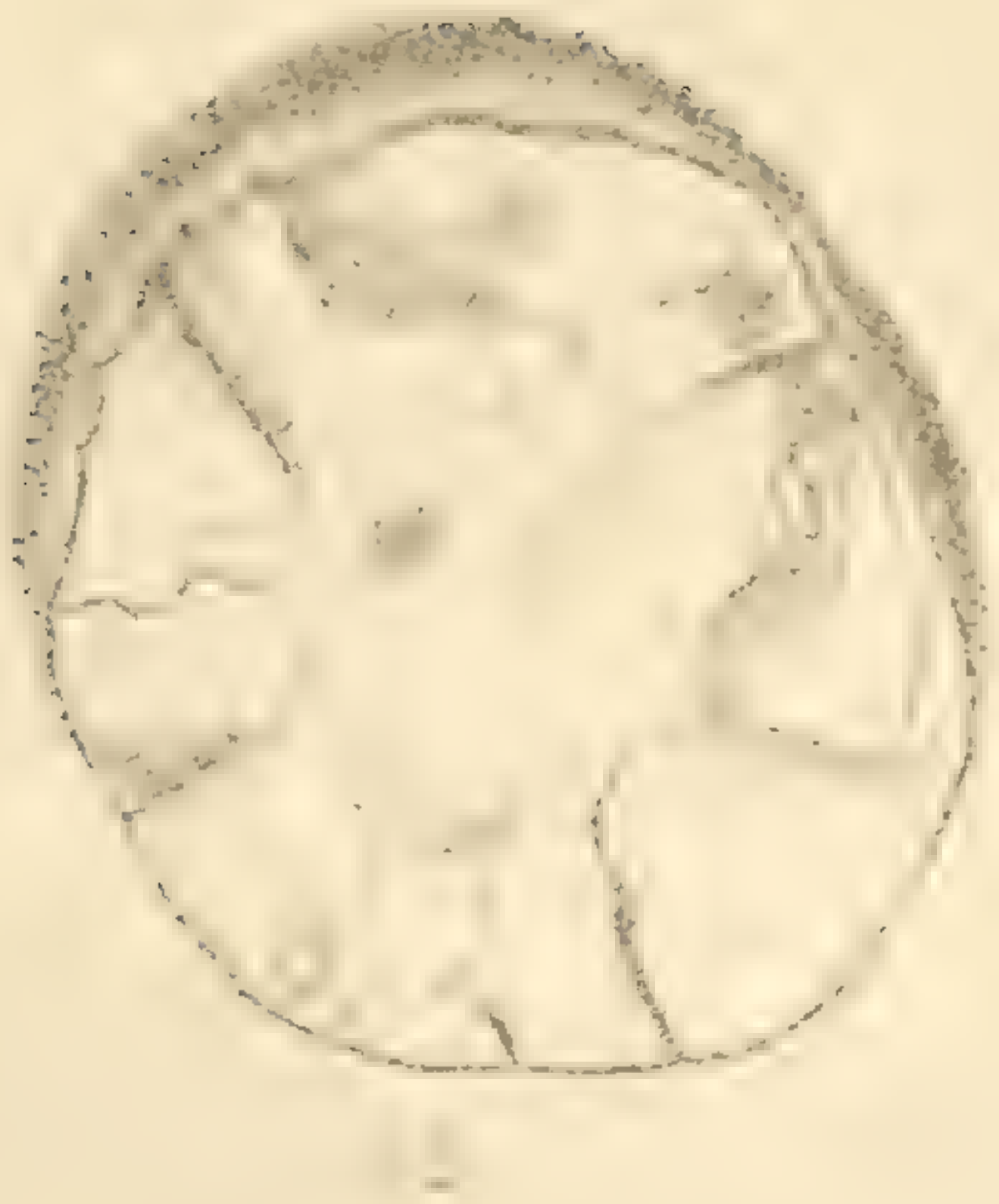

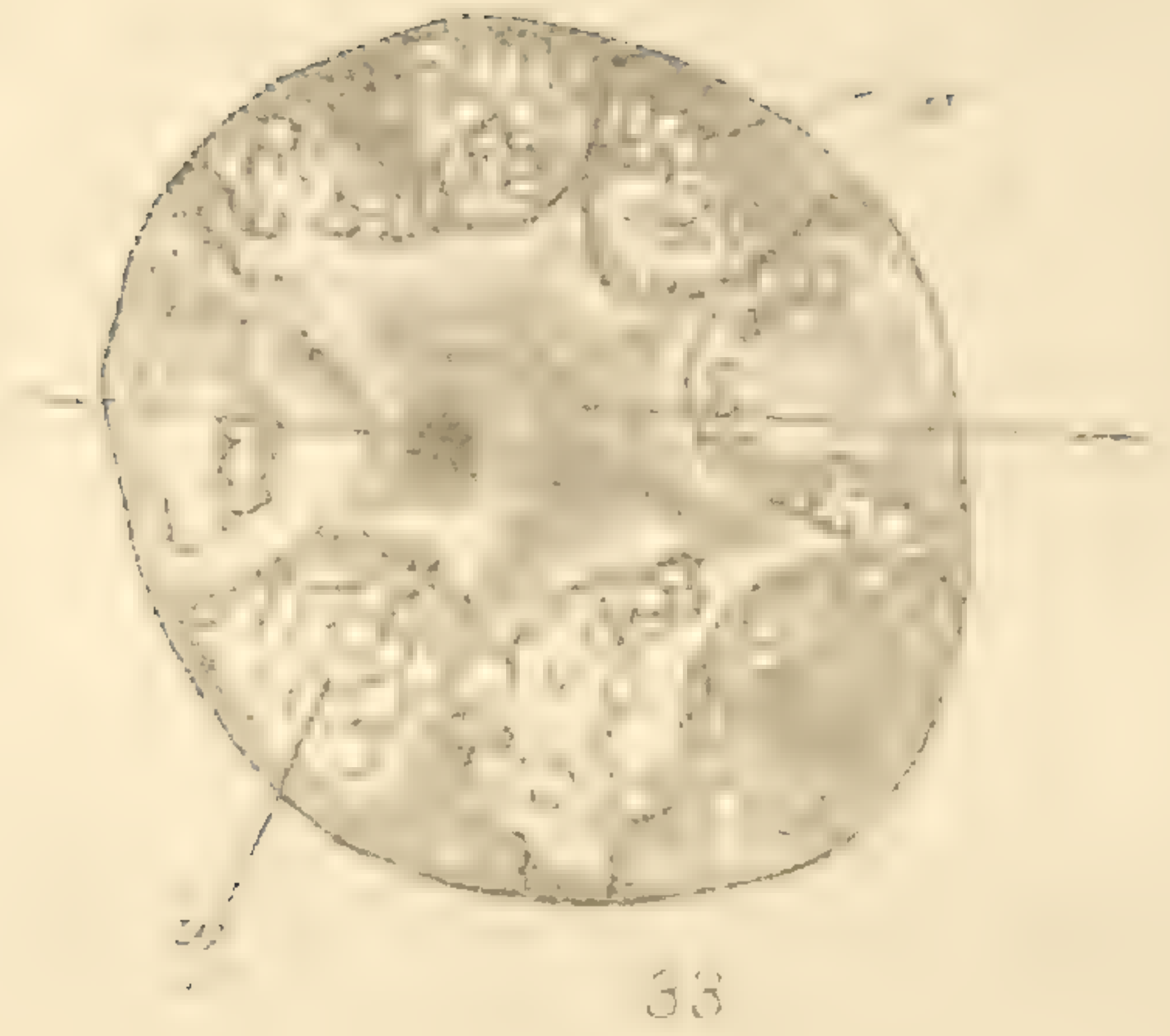

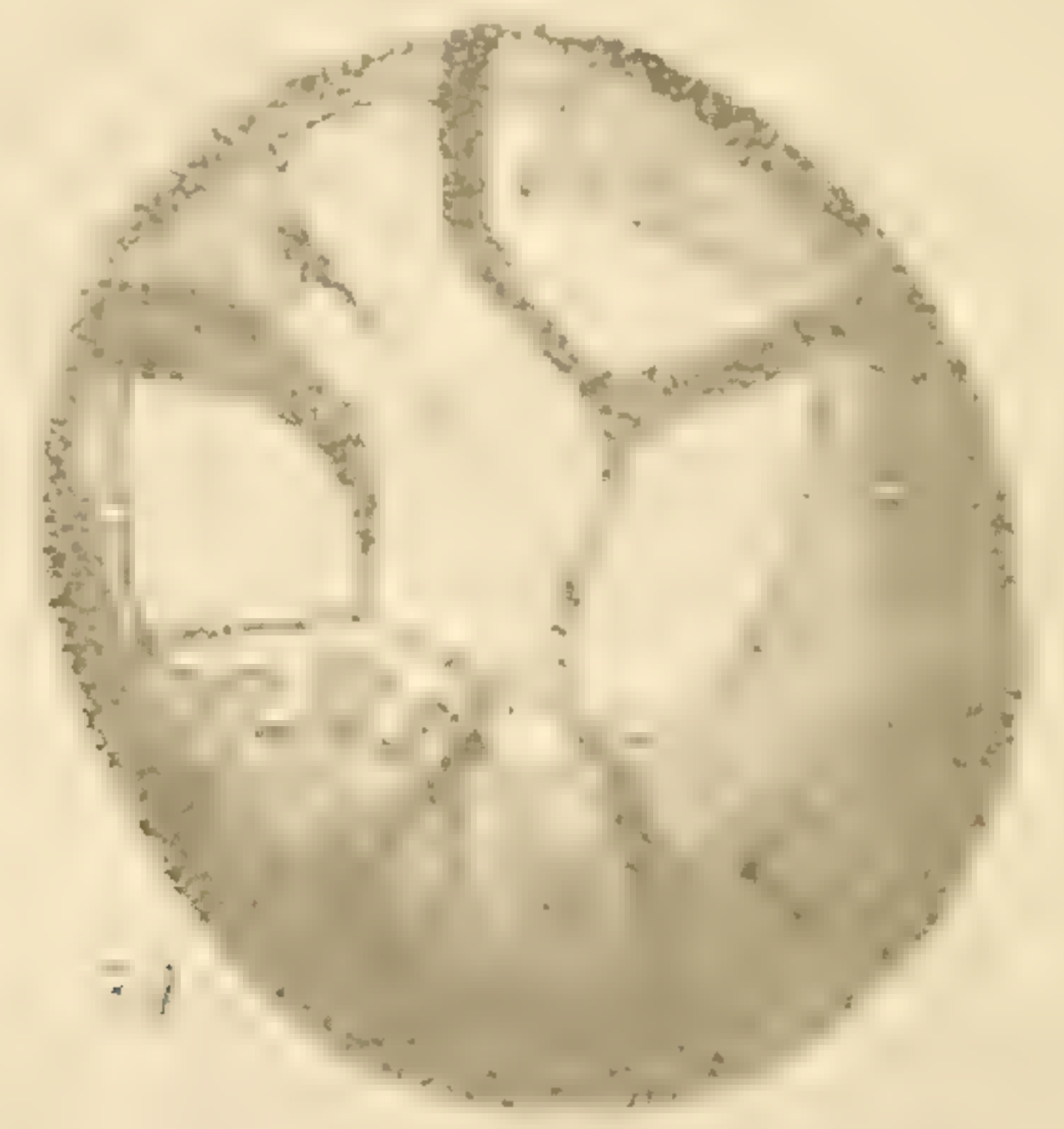

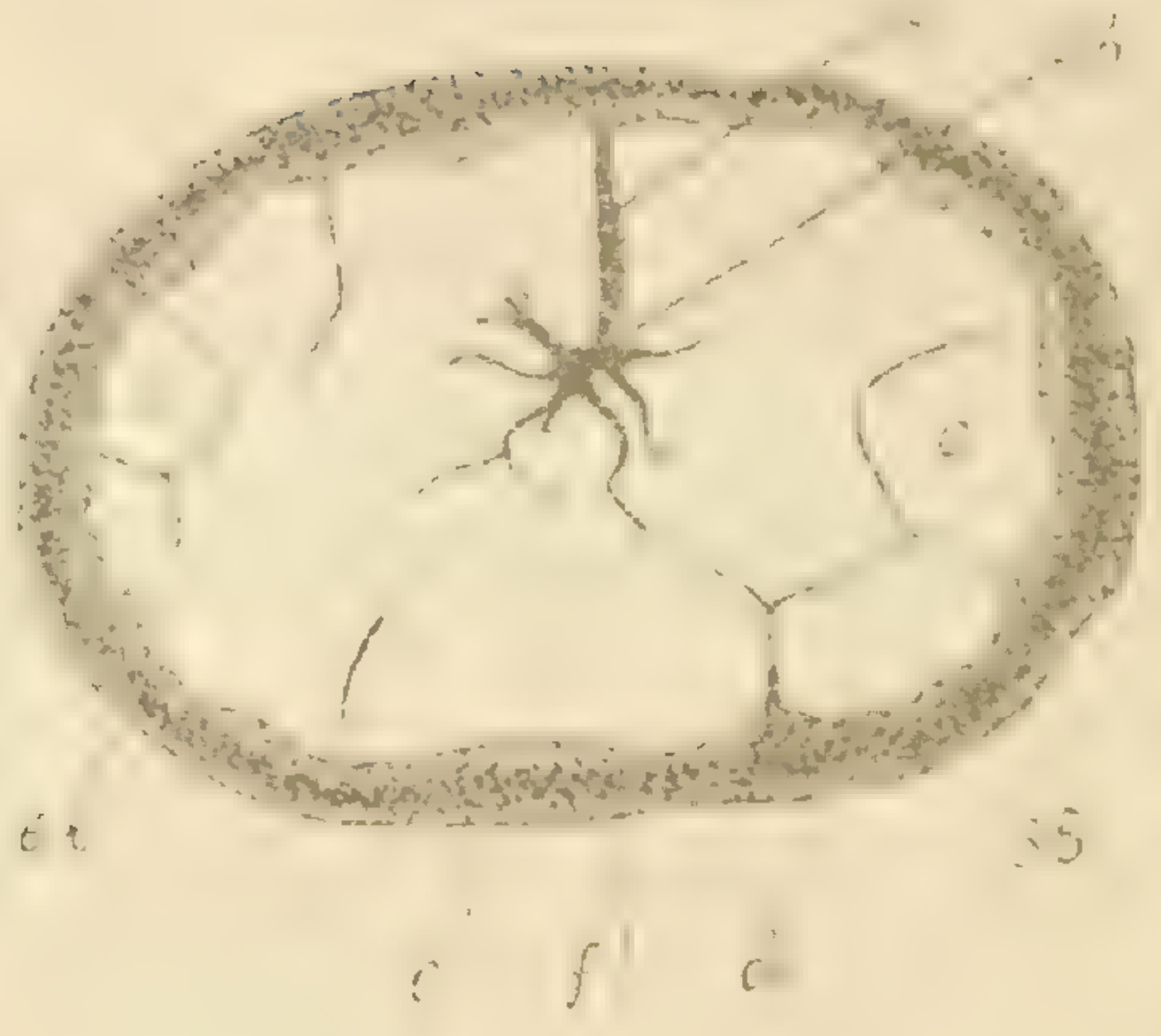

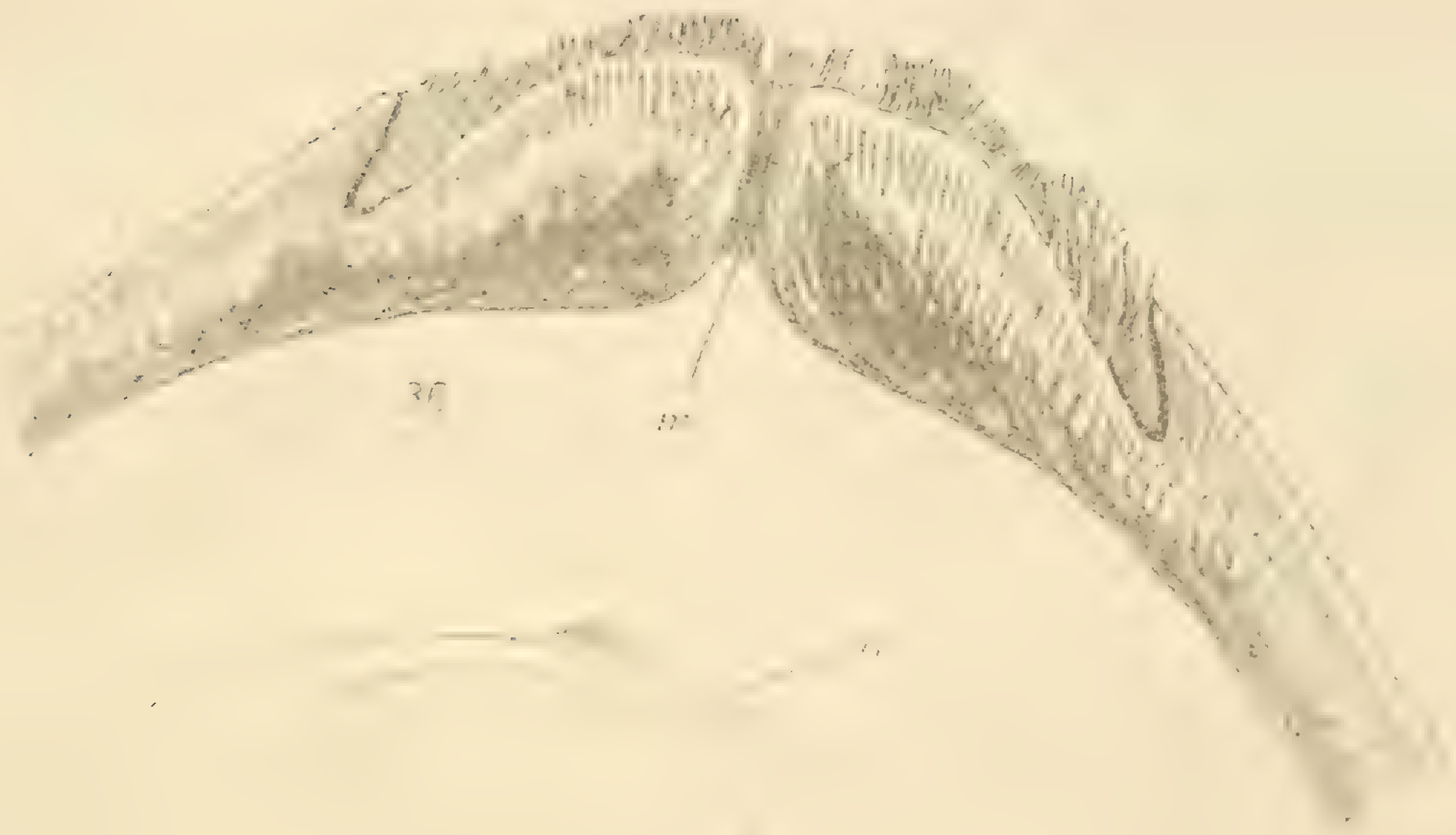

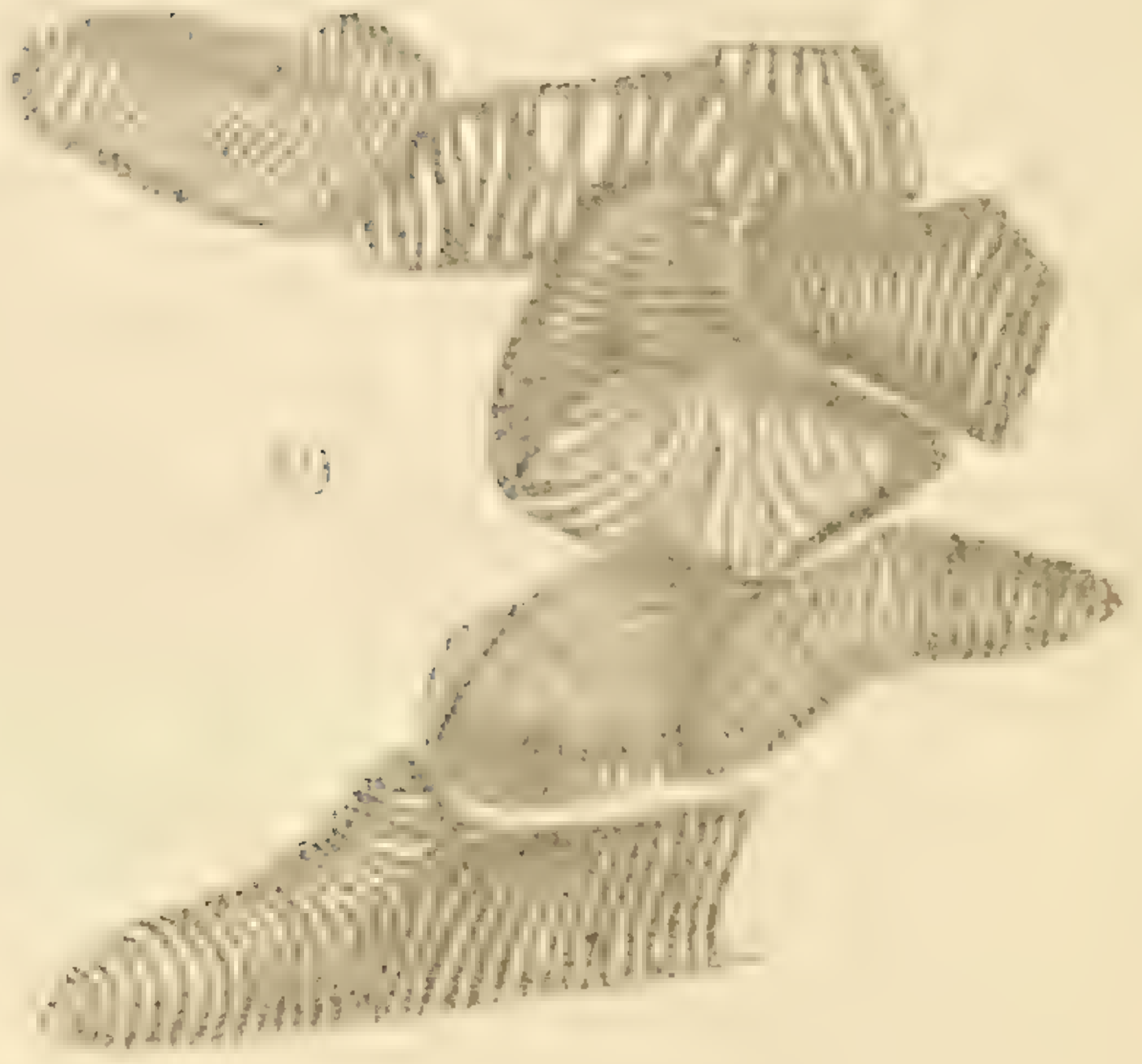

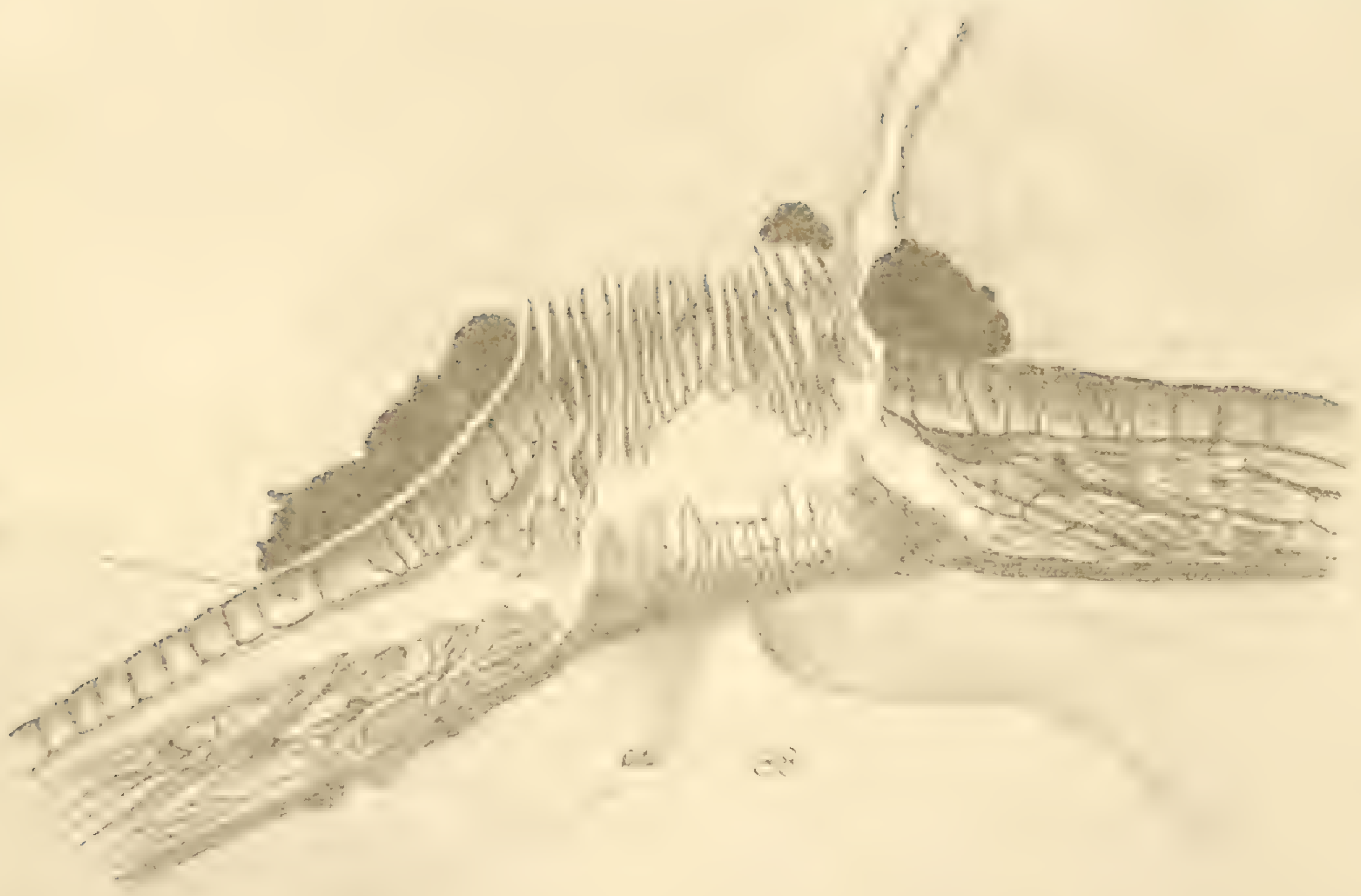

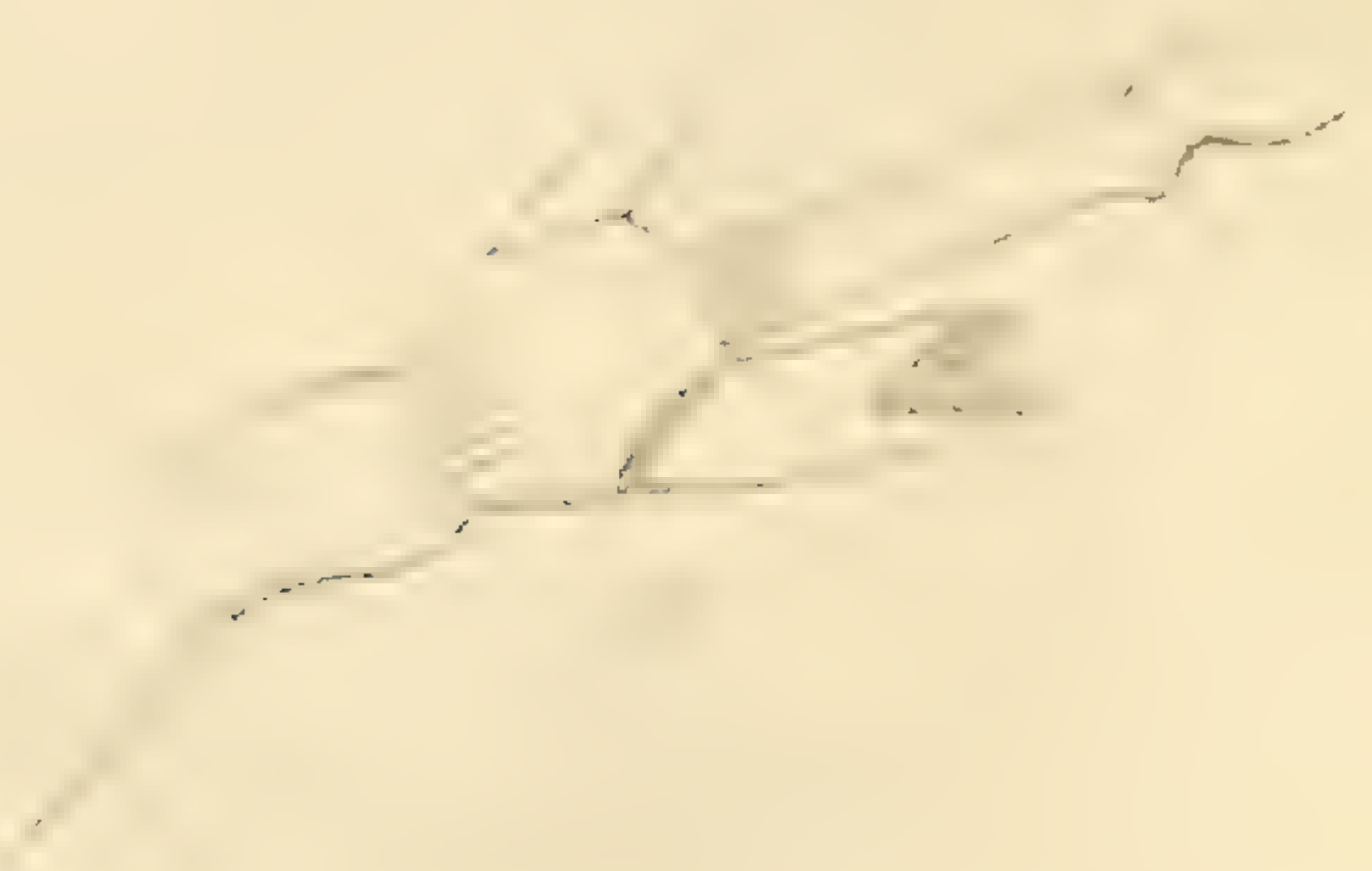

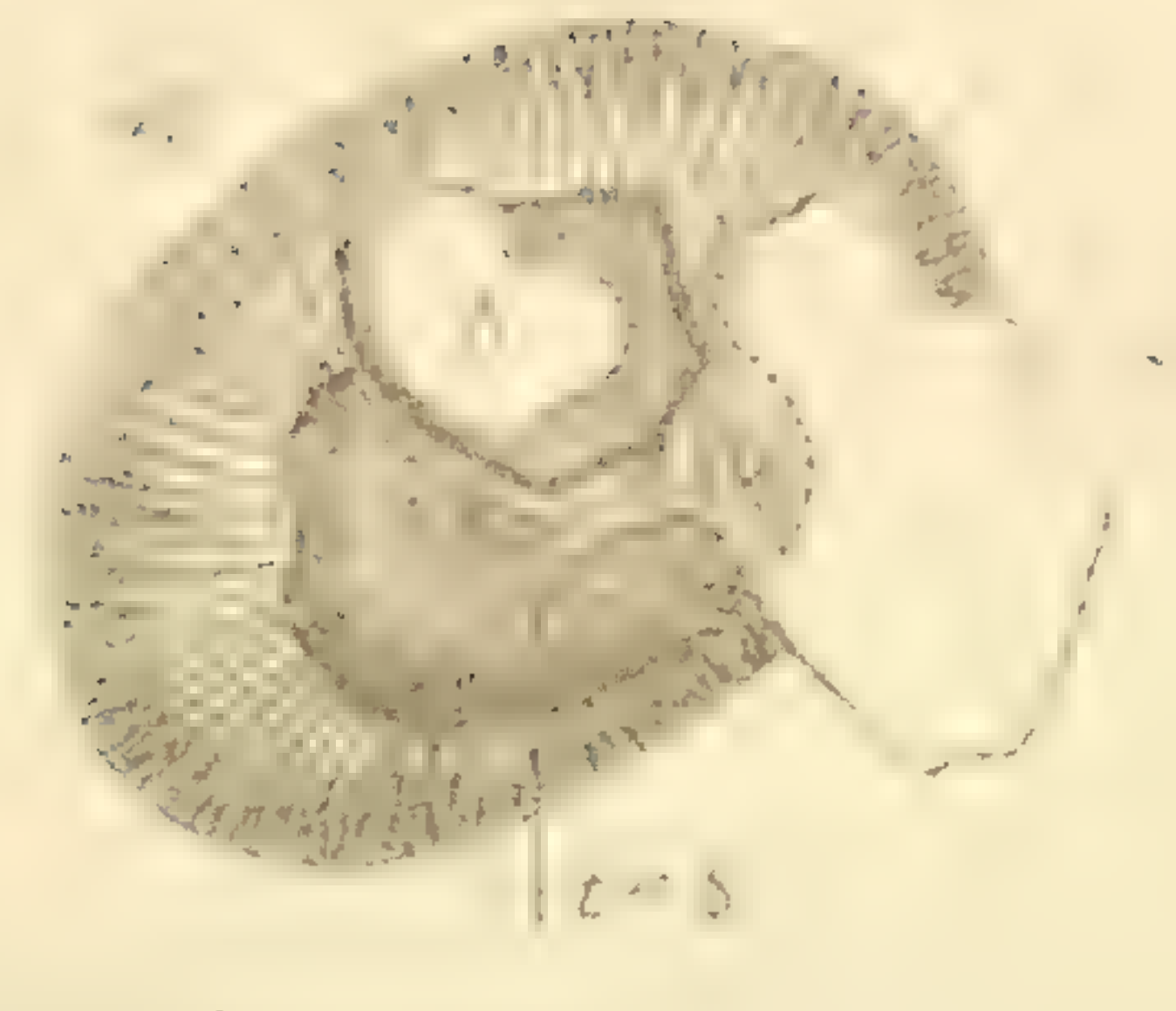

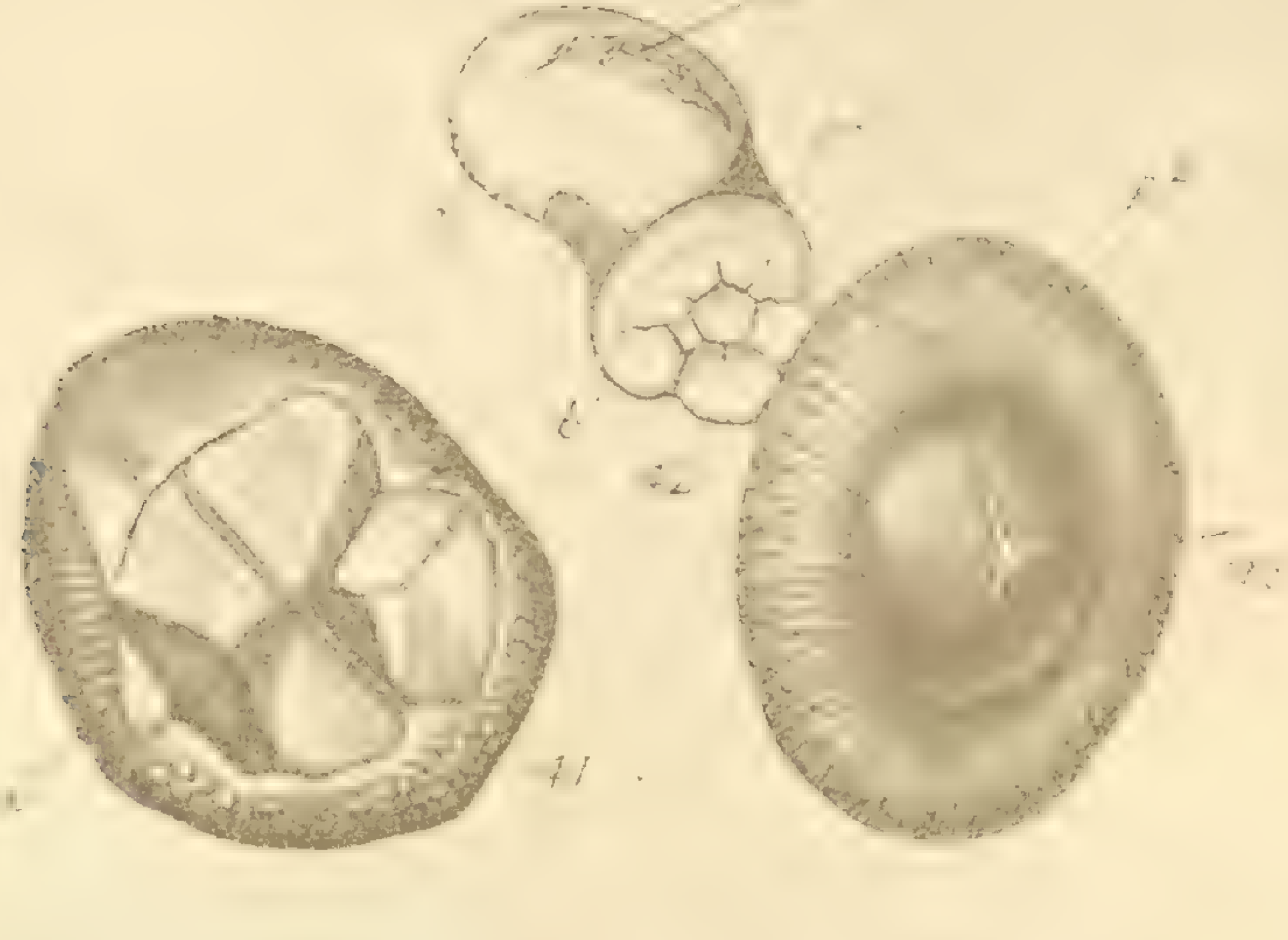

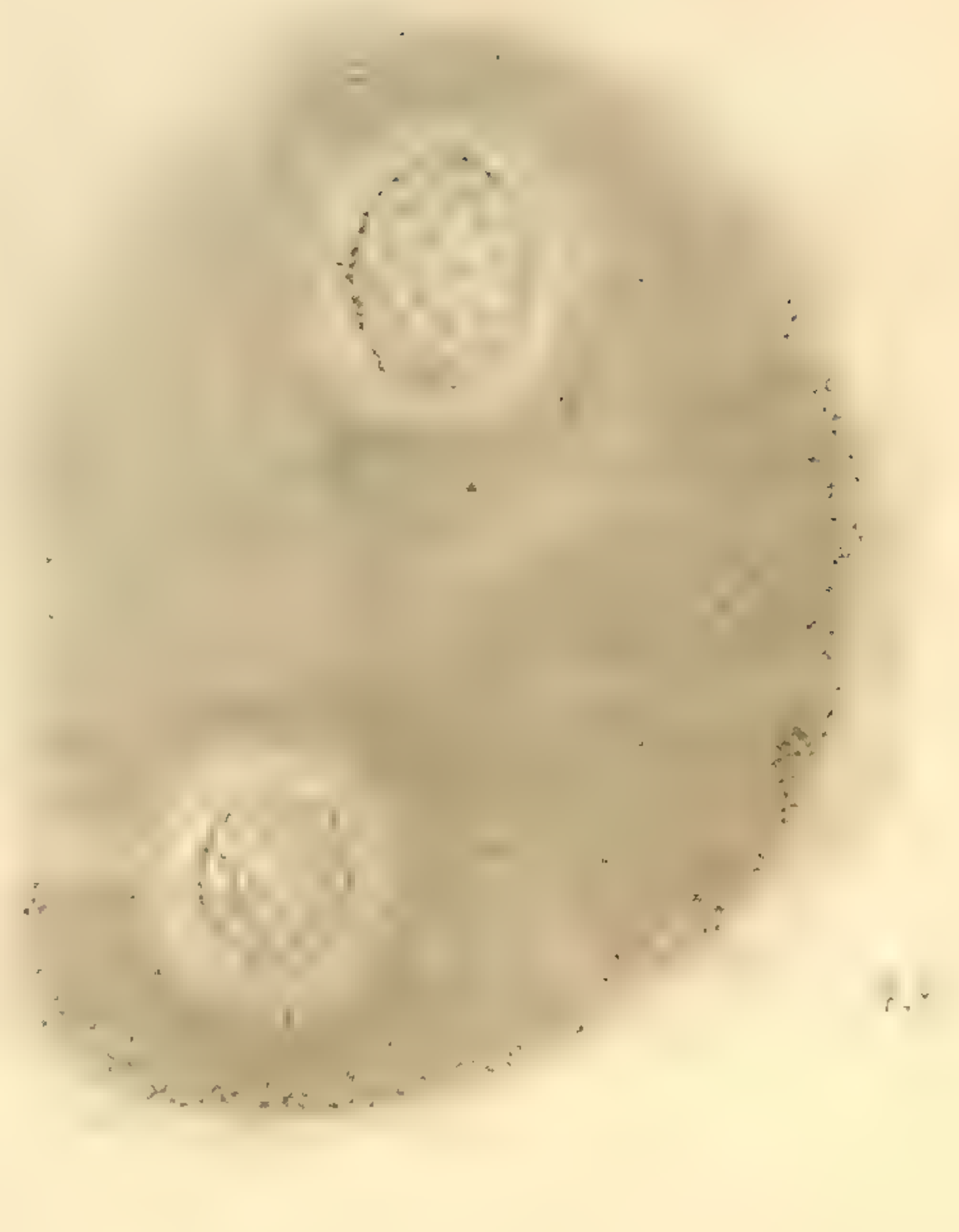

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STRUCTURE OF STEPHANOSPERMUM

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THE

TRANSACTIONS

OF

THE LINNEAN SOCIETY OF LONDON.

ON THE

FRUIT OF MELOCANNA BAMBUSOIDES, TRIN., AN ENDOSPERMLESS, VIVIPAROUS GENUS OF BAMBUSEÆ.

BY

DR. OTTO STAPF, F.L.S.

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June 1904.

IX. *On the Fruit of* Melocanna bambusoides, *Trin., an Endospermless, Viviparous Genus of* Bambuseæ. *By* Dr. Otto Stapf, *F.L.S.*

(Plates 45-47.)

Read 20th March, 1902.

> "Die ganze Lebensweise der Gewächse beruht auf Anpassungsverhältnissen, und die morphologische Ausbildung ihrer Organe wird erst unter dem Gesichtspunkte der Anpassung verständlich."—Wiesner, *Biologie der Pflanzen*, p. 9.

AMONG the Bambuseæ there are three genera the fruits of which are described as large or very large caryopses, either with a coriaceous pericarp and a fleshy seed, or with a very thick, fleshy pericarp. Some of these fruits have been figured, and however meagre the figures may be in details, they suggest at once an unusual deviation from the typical structure of the grass fruit. The genera are *Melocanna*, *Melocalamus*, and *Ochlandra*, and I will summarize briefly the little we know about the structure of their fruits before dealing with the special subject of this paper.

Melocanna is supposed to comprise two species, like *Melocalamus* natives of Eastern Bengal and Burma. I shall have to say more about the number of species later on, and will confine my remarks in this place to the fruit of what is generally known as *M. bambusoides*, Trin. This fruit was first described and figured by Roxburgh in his 'Plantæ Coromandelianæ,' iii. pp. 37, 38, tab. 243, in 1819, as the fruit of a new species of *Bambusa*, viz. *B. baccifera*. According to the diagnosis, it is "a very large, pendulous, pyramidal, one-seeded berry," and according to the description, "a very large, hard, fleshy, conical, smooth, taper, curved, pointed fruit with a single large oval seed." The figure of the fruit in the plate quoted above is very well done, but the longitudinal section, which is also shown, does not pass through the axis of the embryo, and gives therefore an inadequate idea of the structure of the seed, which was no doubt the reason why it has so long remained unknown. Trinius recognizing a new genus in Roxburgh's *Bambusa baccifera*, proposed (in Sprengel, Neue Entdeck. ii. (1821) p. 43), two years after the publication of the 'Plantæ Coromandelianæ,' the name *Melocanna* for it, and *M. bambusoides* for the species. Not having seen specimens, he ventured to explain the structure of the fruit by assuming that the fleshy case containing the seed was formed by the thickening and fusion of the lodicules, "ungefähr wie sich die Blumenschuppen von *Taxus*, *Juniperus* und ähnlichen zur Beere bilden." This explanation of the very singular fruit was suggested to Trinius, as he himself says, by the three swellings at the base of the fruit shown in Roxburgh's figure. All later references to *Melocanna* up to the publication of Munro's "Monograph of the Bambuseæ" (in Trans. Linn. Soc. xxvi., 1868) are based on Roxburgh's description, adding no fresh information on the subject. Nor did Munro himself see specimens of the fruit of *Melocanna*, but he quotes a few lines from a communication by W. Theobald, of the Geological Survey of India, who had observed the plant in Arakan, and writes "that the true seed inside the fleshy pericarp, about the size and shape of a small betel nut, is very pleasant eating, and not at all austere, though without much flavour. The natives declare the whole fruit is edible after baking" *. Munro, like Trinius, could not resist the temptation to speculate on the morphology of the fruit he knew only from a picture and a description, but which must have appeared to him very anomalous indeed. In speaking of the "berry-bearing Bamboos" (among which he counted, by the way, also genera which have no baccate fruit) he says, Trans. Linn. Soc. xxvi. (1868) pp. 4–5:—"They are all extremely interesting from their peculiar fruit. The pistil generally appears to be contained in an envelope somewhat analogous to the sac, or utricle, or perigynium, which contains the seed of *Carex*. In the young state this is so closely attached to the style that it is almost impossible to separate it; in advancing to maturity it increases in various ways. In *Melocanna bambusoides* it becomes very fleshy, and the fruit attains the size of a largish pear." Munro's hypothesis, which is practically a repetition and extension of Trinius's explanation, was disposed of by S. Kurz, who had had an opportunity of studying the fruit of the "berry-bearing Bamboos" more closely. He writes in the 'Indian Forester,' i. p. 266, referring to Munro's theory, "But this view, on a more careful examination, has turned out to be unfounded, for this supposed perigynium is virtually nothing else but the indurated outer wall of the ovary (pericarp), while the inner stratum of looser cells becomes detached from the outer wall and remains as a spongy mass round the true seed." Speaking in another place (*l. c.*) especially of *Melocanna bambusoides*, or, as he calls it, *Melocanna baccifera*, he says:—"Still more interesting are the fleshy fruits of *Melocanna baccifera*, which attain 4 inches by 3, and besides terminate into a fleshy beak about 2 inches long, so that the whole length amounts to 5 inches! Here the seed is comparatively small, while it is the fleshy pericarp which makes the fruit so bulky. These also germinate while still growing on the plant, and Mr. W. L. F. Robinson of Rungpore thus describes the germination: 'A good watch was kept on those fruits on the trees, and the result is this, as they get ripe, out of the big end, by which they hang from the tree, springs a young bamboo leaf and also a bunch of roots; when the young shoot is some 6 in. long, the whole thing drops off the tree, and apparently plants itself in the ground by the roots. It seems a queer thing that the bamboo should reproduce itself on the tree without going to the earth first.'" Unfortunately, Kurz stopped short of examining the seed, and it does not seem to have struck him at all, that the structure of the seed itself was at least as singular as that of the pericarp. Gamble has reproduced ("Indian Bambuseæ," in Ann. Bot. Gard. Calcutta, vii. tab. 105. fig. 9) a crude figure of a fruit in longitudinal section from a drawing by Kurz, preserved in the Calcutta collection. It is evidently a tangential section, passing through the seed near its periphery, and therefore showing a central cavity with a mere fragment of the scutellum, of course without any trace of differentiation, a figure which if compared with the ordinary grass fruit is unintelligible and necessarily misleading. No botanist since Kurz seems to have examined the *Melocanna* fruit, and even Bentham and Gamble had to fall back on Kurz's description, imperfect as it is.

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* Theobald published later on and independently some further observations on this bamboo in the second edition of Mason's 'Burmah,' ii. p. 101 (1883). Here he says of "*Melocanna* (*Bambusa*) *baccifera*, Roxburgh": "An arboreal bamboo, 50 to 70 feet high. Leaves quite glabrous. Caryopsis ovate, the size of a guava or small pear. This is, I think, the Bamboo I found covering large areas in the Arakan Range. When I observed it, the fruit was formed and pretty closely resembled a green guava, and internally was harder than a potato."

Melocalamus is a monotypic genus. The only species, *M. compactiflorus*, Benth., is found in Eastern Bengal and Burma. Although common enough at certain altitudes, it was until lately collected only once in fruit, namely by S. Kurz, who described it in Journ. As. Soc. Beng. xlii. (1873) pt. II. p. 252, and in his 'Forest Flora of Burmah,' ii. p. 567, and figured it in the 'Indian Forester,' i. (1875) p. 266, tab. ii. fig. 13. He says of the fruit in the 'Indian Forester,' *l. c.*: "*Pseudostachyum compactiflorum* (Kurz's synonym for *Melocalamus compactiflorus*) has irregularly globose fruits, the size of a small woodapple, which germinate already while still attached to the mother plant. This has the largest seed of all bamboos, the pericarp being thin and coriaceous." The description in the 'Forest Flora of Burmah' amounts to the same; but he adds that the seed is "mealy-fleshy" or "fleshy." The figure quoted above represents two fruits still attached to the branch, and corresponding to the description, no analyses being given. One of the fruits of Kurz's plate has been reproduced by Gamble, 'Indian Bambuseæ,' tab. 84. This is all that is on record with regard to the fruit of *Melocalamus*.

Ochlandra, the last of the three genera mentioned, is represented by several species in the south-west of the Deccan Peninsula, one in Ceylon, and one in the Malay Peninsula. It was already known to Van Rheede, who described and figured a species of it in his 'Hortus Malabaricus,' v. p. 119, tab. 60 (1685), as *Beesha*, adding that the fruit was unknown. Curiously enough, there are, however, two crude figures in the lower left-hand corner of his plate which undoubtedly represent an entire fruit and another in cross-section. The first to describe the genus technically was Thwaites, in his 'Enumeratio Plantarum Zeylaniæ,' p. 376 (1864). He called it *Ochlandra*, and says of the fruit: "Caryopsis maiuscula ovoidea, stylo persistente indurato acuminata, paleis squamisque spiculæ tecta." Munro, in his "Monograph of the Bambuseæ," had nothing to add to this extremely meagre description. Beddome also hardly advanced our knowledge when describing the fruits of three distinct species of *Beesha* (Munro's name for *Ochlandra*) in his 'Flora Sylvatica,' vol. ii. p. ccxxxiv, except in so far as we learn from him that the pericarp of *O. travancorica* is fleshy; but he gave an excellent habit figure of an *Ochlandra* fruit, the largest and the most peculiar in the genus (*l. c.* tab. 324. fig. 11). It is the fruit of *O. travancorica*, and he describes it thus: "Fruit oblong or ovate, fleshy, embraced by the palea, about 1½ in. in diam. and 2½ in. long, with a hard beak about 2 in. long." To this figure Gamble added (*l. c.* tabb. 108 & 109) equally faithful habit figures of the fruits of *O. Rheedii* var. *sivagiriana*, Gamble, and *O. stridula*, Thw., but no dissections.

This concludes the summary of our knowledge of these very singular grass fruits. It is very fragmentary and entirely confined to some of the most conspicuous external characters. In these circumstances I consider it my particularly good fortune that I was, through the kindness of Sir Dietrich Brandis, enabled to examine a number of excellently preserved fruits of *Melocanna*. The first set of fruits was forwarded to him by Mr. A. E. Wild, late Conservator of Forests, Bengal, in the autumn of 1901 *, and it was on them that this paper was based in its original form as read before the Society on March 20, 1902. Before going to press, however, I received through Sir Dietrich Brandis another batch of *Melocanna* fruits from the same source, stated to have been collected in the Chittagong District, and later on a third set, communicated by Mr. N. K. Mukherji, Extra-Assistant Conservator of Assam, and consisting of unripe fruits and flowers gathered in the Garo Hills. As the fruits with which I had been working originally were almost without exception perfectly mature or even germinating, I was frequently obliged to form my ideas concerning the morphologic value of parts of the fruit and the general development by inference from the mature state. Hence more than one point necessarily remained doubtful. The new material, particularly that from the Garo Hills, offered an opportunity for extending my researches to the earlier stages of development and revising my conclusions. I thought it only right to avail myself of it at the risk of considerably delaying the publication, as other work had meanwhile claimed my time. These efforts of broadening and deepening the basis of my investigations resulted in the confirmation—in the essential points—of the conclusions laid down in the short abstract of my paper contained in the Report of the Society's meeting of March 20, 1902 †, in the explanation of certain particulars in the structure of the *Melocanna* fruits which were unknown or imperfectly understood before, and in a more complete account of their development based on the immediate observation of the successive stages. There also was some uncertainty as to the specific identity of the plants figured by Roxburgh in his 'Plantæ Coromandelianæ,' tab. 243, as *Bambusa baccifera*, and by Gamble in his "Indian Bambuseæ" (in Ann. Bot. Gard. Calc. vii. tab. 105) as *Melocanna bambusoides*, and accordingly also with respect to the correct determination of the fruits I had to deal with. I discussed therefore this question in full, so that it might be studied in the field. The new material, however, dispelled my doubts, which, as it now appears, had been caused by the very remarkable heteromorphy of the inflorescences of *Melocanna bambusoides*, a condition hitherto unknown. Hence I cancelled the paragraph dealing with the suspected identity of the plant depicted by Roxburgh and Gamble respectively, reserving a full description of the inflorescences, as being beyond the limits of this paper, for another occasion.

My original intention was to include the fruits of *Melocalamus* and *Ochlandra* in the scope of my investigations; but considering the scantiness of the material pertaining to those genera to which I then had access, I preferred to confine myself to *Melocanna*. I hope, however, before long to have an opportunity of publishing an account of the structure of the fruits of *Melocalamus* and *Ochlandra*, of which I have since received good material through the courtesy of Sir Dietrich Brandis and Mr. T. F. Bourdillon, Conservator of Forests, Travancore.

I am also under great obligation to Mr. J. S. Gamble for the loan of his herbarium specimens of *Melocanna*, to my friend Prof. Hans Molisch of Prague and to Mr. G. F. Herbert Smith of the Mineralogical Department of the British Museum for the examination of certain crystals found in the fruits, and finally to Mr. L. A. Boodle for assistance in several points which I shall have an opportunity of mentioning in this paper.

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* Kew had received a few equally good specimens from the same source in 1900, but as they were reserved for exhibition purposes in the Museum, I did not include them in my investigations beyond an examination of the external features.

† See 'Nature,' vol. lxv. p. 548.

I. The Species of Melocanna and their Distribution.

The genus *Melocanna* is confined to India. Two species are described and figured by Gamble in his 'Indian Bambuseæ' as belonging to it, viz. *M. bambusoides*, Trin., and *M. humilis*, Kurz.

Melocanna bambusoides ranges from the Kamrup District on the north side of the Khasia Hills to the Attaran District in Tenasserim, inhabiting a belt which lies entirely within the zone of heavy rainfall (over 2000 mm. per annum) *, but with a distinct dry and rainy season, the latter covering approximately the months from May to October. The "locus classicus" of Roxburgh's *Bambusa baccifera*, the basis of the species, is somewhere in the "Chittagong Mountains," whence a Mr. Richard Pierard sent "growing plants, seeds, and well-preserved specimens" to Roxburgh, as it seems, in 1801; this, at least, is the date given in Roxburgh's 'Hortus Bengalensis,' p. 25. The locality is not further specified, but as Pierard says, in his note to Roxburgh, that the bamboo "grows in dry places, chiefly on the sides of hills, where the upper stratum of the soil is sandy," I infer that he meant the lower outer ranges, which in part consist of sandstone.

The second species, *M. humilis*, was described by S. Kurz from barren specimens and must not be confused with *M. humilis*, Rupr., which is an Amboina plant, figured by Rumphius and evidently not a *Melocanna* at all. Kurz indicates his *M. humilis* from the mixed forests of Arakan and from the Pazwoondoung Valley, Pegu. It may be a *Melocanna*, but so very little is known that I may well pass it over.

Finally, I wish to point to what seems to be a third species of *Melocanna*. My attention was called to it by a specimen consisting of a leafy twig and the end of a very curious stolon. It was collected by C. B. Clarke at Eerung in Muneypoor and numbered 42188 *a*. The leaves are very like those of *Melocanna bambusoides*, but the stem is described on the label as thorny. Mr. C. B. Clarke has kindly supplied me with a note on this bamboo, which will, I hope, lead to its rediscovery and thorough examination. He writes :—"When I was at Dacca in 1868, an officer, who had been on survey in the East Cachar Hills, showed me a large seed of *Melocanna*, as big as that depicted by Roxburgh. He told me that this bamboo occupied 6000 square miles of country; that it had fruited the last season; that he stopped his survey six weeks earlier owing to the fall of seeds breaking theodolites and plane tables; that the whole of the old plants had died after seeding; that the whole country could be seen covered with seedlings. Subsequently, in 1885, I marched from Muneypoor to Cachar, across the country reported to me by the surveyor in 1868, and was for several days in a uniform, almost pure, jungle of *Melocanna*. The powerful stolons formed a horizontal mass, and I with difficulty dug up the end of one, now in the herbarium at Kew. The stems of this bamboo, erect, solitary, about 1–2 yards apart, occupied the ground almost exclusively, with no jungle under them, and shut out all view. The stems were, by recollection, 1½ in. in diam., about 30 feet high, leafy at the top, yellow, with spines at every node. The specimen now in Kew has no piece of the stem, but it has the note, made on the day of collection, mentioning the thorns on the stems. Though the stems stood a yard or two apart, the jungle was most tedious to penetrate, unless you allowed the clothes to be torn from your back and the flesh from your bones. I noted the plant at the time as a species different from the *Melocanna bambusoides* of Herb. Kew. (in which I was possibly right, as I then knew the latter by sight). In the jungle covered by this thorny *Melocanna*, which came into fruit all simultaneously after growing 40 years or so vegetatively, it would be difficult to place a plane table so that the seeds should not fall on it. It is a most dreary country to march in; when you reach the top of a hill, there is no look out."

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* Bartholomew, Phys. Atl. vol. iii. pl. 25.

II. Habit of Melocanna bambusoides.

Melocanna bambusoides is described by Gamble ('Indian Bambuseæ,' p. 118) as "an evergreen, arboreous bamboo, with single distant culms arising from the ramifications of an underground rhizome. Culms tall . . . . unbranched till near the top, 50–70 feet high, 1·5 to 3 in. in diameter . . . . Owing to its habit of sending out long underground rhizomes which give out culms at intervals, it spreads very rapidly and is extremely difficult to get rid of." Like many other bamboos it loses its foliage when it begins to flower (Roxburgh, Plant. Coromand. iii. p. 38). When finally deprived of all its leaves the top with its numerous inflorescences borne on the gigantic culm, as on a peduncle, presents a singular appearance, which suggested to Kurz "an ample, after the fall of the leaves, radical panicle" (Forest Flora of Burmah, ii. p. 569). Kurz went too far in thus reducing the whole of the flowering culm to a single panicle, and it appears to me certainly more expedient to confine the term "inflorescence" to the dense aggregations of spikelets which terminate the flowering branches above a succession of perfect leaves (with early deciduous blades) and to their lateral and basal homologues, whether they are preceded by perfect leaves or not. These flowering branches are gathered in fascicles springing from the nodes of the culm and its branches in the region of the top of the bamboo. They vary not only in size and number, but also very considerably in structure and habit, as a comparison of Roxburgh's and Gamble's plates will show, so much so, indeed, that the figures depicted there suggest distinct species. In reality, they represent only the two types of inflorescence of which the fascicles are made up, either so as to contain only inflorescences of one kind or a combination of both. One set of inflorescences may be described as androdynamous, namely predominantly or exclusively male, the other as gynodynamous, namely predominantly or exclusively female, hermaphrodite flowers occurring occasionally in either. Intermediate forms exist, but they are very rare. There are consequently three conditions possible in the grouping of the inflorescences: (*a*) uniformly androdynamous fascicles, (*b*) uniformly gynodynamous fascicles, and (*c*) mixed fascicles. How they are distributed over the top of the bamboo, or whether there is ever an approach to diœcism, I cannot say. The fruits are, of course, produced mainly on the gynodynamous inflorescences, slender spikes from a few to 30 cm. long. Where they occur in androdynamous inflorescences which represent much decompound panicles, they are always few and usually terminal or subterminal on the branches or branchlets bearing them. They spring from sessile, 1–2-flowered spikelets, the bracts (glumes, valves, pales) of which persist after flowering in an unchanged though withered condition. Nor does the axis of the spikelet which acts as a very short fruit-stalk outwardly suffer any transformation, the necessary strengthening being provided for, here as well as in the axes of the inflorescences, by internal changes resulting in the development of sufficient mechanical tissue. Thus the fruits hang, by means of very short and slender stalks of great tensile strength, from the flexible and wiry axes of the inflorescences.

III. Duration of Life ("Flowering Period").

Melocanna bambusoides is, like many other bamboos, so far as we know, monocarpic. It is a gregarious plant forming extensive forests, and flowers and fruits simultaneously over large tracts at long periods, each period corresponding to one generation. Kurz (in 'Ind. Forester,' i. p. 257) says it flowers and fruits in Arakan every 30 to 35 years. The dates of flowering and fruiting which I have been able to ascertain are: 1801 for Chittagong (Pierard in Roxburgh, Hort. Beng. p. 25), 1849 for Tenasserim (Falconer in Hb. Kew.) *, 1863–1866 for the Botanic Garden, Calcutta (Gamble, Ind. Bamb. p. 120), 1864–1865 for Arakan (Kurz, *l. c.* p. 258; this is evidently the fruiting to which Theobald refers in Mason, 'Burmah,' 2nd ed. ii. p. 101), 1889 for the Garo Hills (specimen in Gamble's herbarium), 1892 for "Assam" (Gamble, *l. c.*), and 1900 to 1902 for the Garo Hills, Cachar, and Chittagong (specimens received by Sir Dietrich Brandis). It is clear from these dates that we cannot speak of a *general* "flowering period" of 30–35 years in the case of *Melocanna bambusoides*, although it may be quite true that the normal duration of life of this monocarpic bamboo is 30–35 years. We can hardly assume *a priori* that the flowering should take place simultaneously (or, what is about the same, that all the individuals of this species should be of the same age) over the whole area with its varied conditions of soil and climate, and in fact we know that this is not the case with other gregariously flowering bamboos (see Brandis in 'Indian Forester,' xxv. 1899, p. 10). The dates for the Garo Hills—to which that for "Assam" may be added, as by "Assam" no doubt the south-western corner of the Kamrup District is meant—are particularly instructive, as we learn from them that flowering took place at least three times during a period of about 12 years within a limited area. There is, however, no evidence to show what portions of the area were affected each time, or how far the flowering was general in the affected portions. More numerous observations, extending at the same time over the whole area, are necessary, in this as in the case of other "periodically" flowering bamboos, before we can understand this remarkable "periodicity."

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* A flowering specimen, collected by Falconer in "Moulmein," was formerly in the Kew Collections. According to a note it was sorted out because it was identical with another flowering specimen cut by Kurz in the Botanic Garden, Calcutta. Falconer was in Moulmein and the Attaran District early in 1849, and I assume the specimen was then collected, although he does not mention it especially in his "Report on the Tenasserim Teak Forests."

IV. GENERAL FEATURES OF THE MATURE FRUIT.

The mature fruits are ovoid to globose (Pl. 45. figs. 1–7), passing above into a short or even obscure, or long and then more or less curved beak. They vary much in size. Whilst the smallest which I examined measured 4 by 3·5 cm., the corresponding figures of the largest were 12 by 5·5 cm. The weight also varies accordingly from 47 grams to 180 grams. The fruits are glabrous, smooth or somewhat wrinkled, green, fleshy, but hard and tough. Nearly always 3, or sometimes 5, faint, obtuse, longitudinal ribs may be observed, one of which descends towards the palea and may therefore be termed ventral, whilst the other two are lateral. Opposite to the ventral ridge a shallow and often very obscure groove extends towards the base, ending close to the point of attachment of the fruit. Here a slight swelling (figs. 1, 3, *et.*), covered by the valve or floral glume, indicates the spot where the embryo breaks through the pericarp in the course of germination. This embryo spot or embryotegium is, however, by no means so distinctly defined as in typical grass fruits, nor is there any trace of a hilum discernible.

A section in the median plane (Pl. 45. fig. 3) of the fruit reveals the following main features of the internal structure:—

1. A hard, fleshy, thick *pericarp* (Pl. 45. figs. 3, 5, 7, *p.*), of a very homogeneous substance, enclosing an oblong cavity, extending from the embryotegium to about $\frac{2}{3}$ or $\frac{3}{4}$ of the length of the fruit (exclusive of the beak), and of approximately central position, its greatest diameter being equal to about $\frac{1}{3}$ of the diameter of the fruit.

2. A delicate layer (Pl. 45. figs. 3, 5, 7, *d.*), lining the cavity and almost indistinguishable to the naked eye, but discernible under the lens as a fine membrane or in cross-section as a fine line of a substance different from that of the pericarp. This layer I call the *diaphragm*.

3. The *embryo*, consisting of the embryo proper (Pl. 45. fig. 3, *pl.* & *r.*), situated close to the embryotegium, and a many times larger fleshy body (figs. 3, 5, 7, *sc.*), the equivalent of the scutellum of the typical grass seed, filling up more or less completely the cavity.

This very general description discloses already—apart from the great size of the fruit—*several very remarkable characters which do not occur in the typical grass fruit, viz. the powerful development of the pericarp, the absence of endosperm, the corresponding enlargement of the scutellum, and the interpolation of a diaphragm film between pericarp and scutellum, to which may be added the vivipary, mentioned in the introductory part.* This deviation from the normal structure of the grass fruit is more or less repeated in the fruit of *Melocalamus* and in a modified form in that of *Ochlandra*, although the latter is not, so far as we know, viviparous. Otherwise it seems to be without a parallel in the large order of Gramineæ, which exhibits so great a uniformity in the structure of the fruit. To understand these very singular modifications and their mutual correlation, it is necessary to examine the development of the fruit from the ovary stage and its internal morphology in the mature condition. This will be done in the next chapters.

V. The Development of the Fruit.

When I read this paper in its original form before the Society, I remarked that I had not had an opportunity of examining young fruits and knew therefore nothing from direct observation of their stages of development prior to almost complete maturity. The material since received, although not so good and complete as might be wished, has filled the gaps sufficiently to enable me to give a more complete account of the development and structure of this remarkable bamboo fruit; but the early stages of the ovule still require close examination.

The pistil (Pl. 45. figs. 8–10) of the hermaphrodite or female flowers is bottle-shaped, very slender and long-exserted from the spikelet, freely exposing three more or less unequal curved, feathery or, as Roxburgh describes them, woolly stigmas. The ovary is not distinctly separated from the style, but passes imperceptibly into it; but if we estimate its length by that of the ovarial cavity, we find it to be several times shorter than the style. The pistil is more or less distinctly 5-grooved from the base upwards to or beyond the middle, the ridges separating the grooves being so placed, that one is ventral (fig. 2, 15, *vr.*), *i. e.* facing the palea, whilst the others are lateral, the ventral ridge being generally the least prominent of them. The body of the pistil consists mainly of small-celled parenchyma and is traversed longitudinally by 15 or more vascular (fig. 15) strands, the position of which is marked in cross-sections of the fruit by the presence of usually solitary tracheids. Their disposition is, however, apparently quite independent of the orientation of the ovule.

The ovule (Pl. 45. figs. 12–15) is in the position usual in Gramineæ. In the mature pistil it is 1–1·5 mm. long and very slender, and on the whole small in comparison with the ovary, its diameter being only $\frac{1}{3}$–$\frac{1}{4}$ of that of the ovary. It is attached to the pericarp with a very broad back, with the exception of the short, free, somewhat oblique and basiscope apex, and fills the ovarial cavity so completely that the latter appears in cross-sections made from spirit-material as a very slender crescent. The ovule-wall thins out towards the front, but there is no differentiation into integuments and nucellus, and accordingly also no micropyle. *The ovules are therefore actually naked.* Still there is this to be observed, the cells of the two outermost layers of the ovary-wall (fig. 14) are slightly larger than those of the following inner tissue, and they stain with Schultz's solution yellow, whilst the cell-walls of the remainder of the ovule stain blue, a reaction which indicates the first stage in the disorganisation which the peripheral portion of the ovule-wall undergoes, as I shall have to show presently. The small-celled tissue which surrounds the very large embryo-sac (Pl. 45. figs. 13–15, *es.*) in the front half of the ovule continues also over the back, where it passes gradually into cells of greater diameter, such as build up the bulk of the pistil. How the pollen-tubes reach the egg-cell, I cannot say, having never seen a trace of them in the ovarial cavity, nor was there an indication of a stigmatic channel or a conducting-tissue. I was also unable to trace the early stages of the development of the embryo, as the smallest I came across was 3 mm. long and already distinctly differentiated (Pl. 45. figs. 22, 23).

There would therefore be a considerable gap in my account of the development of the fruit, but for the light which certain remarkable young fruits from the Garo Hills threw on the earlier phases. These fruits ranged from the earliest stages to that of almost complete maturity. They (Pl. 45. figs. 16–18) were mostly normal to all outward appearance, but never contained a trace of an embryo, representing evidently a case of imperfectly efficient fertilization, similar to that of seedless raisins, citrons, hops, or Crucifers †. Apart from the absence of an embryo and certain changes in the apex of the ovule immediately dependent on the presence of the embryo, the development of the fruits was no doubt essentially that of normal fertile fruits. The changes in the apex of the ovule just alluded to consist in its being crushed and obliterated by the growing embryo, which, as it enlarges, fills the bottom of the ovarial cavity and pushes its way towards the base of the fruit. No embryo having been formed in the barren Garo Hills fruits, the apex of the ovule took part in the general enlargement of the ovule until in one case it attained the considerable length of 4 mm. (Pl. 45. figs. 18, 19). Making, then, use of my observations on these fruits for the description of the earlier stages of the development of the fruit, I proceed now to give as far as possible a coherent account of it.

The ovule grows, after fertilization, simultaneously with the ovary. The ovarial cavity also expands, but chiefly longitudinally, so as to form a flat linear canal (fig. 16, *oc.**) in front of the embryo-sac. Yet, as the latter grows faster than the cavity expands, this canal is not only left behind in its longitudinal development, but is also gradually closed up, the obliteration beginning from the upper end. It remains, however, for a long time distinctly discernible as a narrow marked strip, situated along or somewhat aside of the middle line of the front half of the embryo-sac, and ascending to about $\frac{1}{2}$ to $\frac{2}{3}$ of its length. As the ovarial cavity closes up, the meeting surface layers of the front and back walls become more or less liquefied or jellified. How early the peripheral cells of the ovule-wall prepare for this change, I have already stated on p. 409. In consequence of this process the ovarial canal may be filled up with a structureless substance (Pl. 45. figs. 20 *oc.**, 21); but as a rule the walls coalesce without leaving a trace of their original separation, or only betraying it, in cross-sections, by somewhat thin bands with the appearance of solidified jelly. Whilst this is going on, endosperm (Pl. 45. figs. 20, 22, *end.*) forms as a delicate film, lining the embryo-sac with a layer of small almost isodiametric cells, which are followed inwards by larger radially lengthened cells (Pl. 46. figs. 30, 31). The thickness of the lining is, however, more or less unequal in different parts, so that its inner surface is very uneven (Pl. 45. figs. 20, 22, *end.*). Occasionally flake-like extensions of endospermatic tissue project far into, or even traverse, as thin strands or lamellæ, the cavity, which is filled with an almost limpid, slightly opalescent liquid. Apart from such exceptional expansions, the endospermatic lining grows rarely thicker than 1 mm., and often remains considerably thinner. The cell-walls of the endosperm are very thin, particularly those of the inner portions, which in some cases were found to be of extreme delicacy. The peripheral endosperm-cells are filled with plasma; the inner contain a decreasing amount of plasmatic wall-lining, and, beside their nuclei, a great deal of oil and a varying but moderate amount of transitory starch. A portion of the oil passes into the liquid filling the embryo-sac, leaving a greasy residuum if the liquid is evaporated. Small quantities of starch and free nuclei were also found in the liquid, probably escapes from cells which had been cut open. This was the condition of the embryo-sac of the young fruit which contained the smallest embryo I observed in the course of my investigations. The fruit measured about 2·5 cm. across where widest, whilst the embryo-sac was up to 1·2 cm. wide and 2 cm. long. The length of the embryo was 3 mm., as already stated, and its distance from the base of the fruit slightly over 3 mm. I may add that the pericarp at this stage contained scarcely any starch. The embryo occupied the base of the ovarial cavity, lying across it. The apex of the ovule was no longer discernible, having been crushed and probably in part absorbed by the growing embryo. The shape of the embryo (Pl. **45.** figs. 22 & 23) at this stage was that of an ordinary grass embryo with a flat shield-like scutellum. Plumule and radicle had been formed and were in the peculiar position which I shall describe later on. Even the bud in the axil of the coleoptile and the initials of the first secondary roots were developed, whilst a considerable number of the protocambial strands could be traced from the base of the plumule into the scutellum. As the fruit continues to grow the embryo-sac and embryo enlarge. The embryo passes basewards and crushes the parenchyma below it, until it lies finally close to the surface covered by a coriaceous piece of dead tissue (Pl. **45.** fig. 3, *ct.*). This downward movement is facilitated by the spongy condition of the parenchyma at the very base of the young fruit. In the case figured on Pl. **45.** fig. 22, a portion of it (fig. 22, at *) about midway between the embryo and the point of insertion of the stalk was even in a state of collapse. Analogous conditions occur also in other viviparous plants and have led to the adoption of the term "Verdrängungsgewebe" (see Goebel, in 'Flora,' lxxxiii. 1897, p. 430). Simultaneously the plumule develops more leaf-primordia, a few more secondary rootlets are formed, and the system of vascular strands gradually assumes the peculiar complicated structure characteristic of the mature embryo of *Melocanna*; but the most remarkable development is that which the scutellum undergoes. Growing from the back which is turned towards the cavity of the embryo-sac, it fills the cavity tightly from the base upwards, either entirely or with the exception of a small portion at the top. At the same time the liquid contents of the embryo-sac are absorbed and the endospermatic lining which has long before collapsed becomes wedged in between scutellum and pericarp and crushed into an apparently structureless (Pl. **46.** fig. 29, *d.*) film. This growth of the scutellum is accompanied by the development of very numerous vascular strands (Pl. **47.** figs 40, 51) spreading in sheaf fashion from the base of the scutellum. Towards the close of the development reserve starch is deposited in the parenchymatic ground-tissue, whilst the epithelium (Pl. **46.** fig. 29, *epth.*) remains from an early stage filled with plasma, proteids, and oil in tiny drops. Before the fruit attains its final size, the pericarp also begins to be charged with starch, with the exception of the innermost 3 or 4 cell-layers, which contain a few minute grains of starch or none at all. Having reached this stage, the fruit may be considered mature. *As appears from the description, it consists of the fleshy pericarp and a naked "seed," the embryo proper lying outside the skinny covering of the diaphragm, or, what amounts to the same, the embryo-sac.*

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† See Noll, "Fruchtbildung ohne vorausgegangene Bestäubung (Parthenocarpie) bei der Gurke," in Sitz.-Ber. Niederrhein. Gesellsch. für Natur- u. Heilkunde zu Bonn, 1902, p. 1. True parthenocarpy is, in my opinion, out of question, considering that the *Melocanna* forests of the Garo Hills must have been full of pollen.

VI. INTERNAL STRUCTURE OF THE FRUIT.

A. *The Pericarp.*

The outer epidermis (Pl. 46. figs. 24, 25) of the pericarp consists of isodiametric polygonal cells of no great depth, with a very limited number of irregularly interspersed stomata (Pl. 46. fig. 25). All the cell-walls, but particularly the side-walls, are considerably and often irregularly thickened and the latter perforated by numerous pits. In consequence of the somewhat unequal size of the cells, and still more of the unequal thickening and the numerous pits, the surface aspect of the epidermis is rather irregular and characterized by the unequally crenulated outlines of the cell-lumina. This irregular appearance is further enhanced by the frequent presence of silica-bodies (Pl. 46. fig. 26) in the cells, which often fill the lumina and make the cells appear solid. Mr. Boodle was good enough to examine for me the epidermis more closely for its silicification. Sections treated with phenol in the way described by Grobb ("Anat. d. Epiderm. Gramineenblätt.," in Bibl. Bot. vii. pp. 14–17) or with Eau de Javelle and clove-oil showed that the cells containing silica-bodies are arranged in irregular groups of sometimes considerable extent and varying shape, and apparently without any definite order (Pl. 46. fig. 26). These silica-bodies may be obtained free either by maceration in Schultz's liquid or by burning. The latter method has the advantage of retaining them in their position, which makes it possible to test the appearances obtained by treating the sections with phenol or clove-oil. This was desirable, as the silica-bodies show up in these media only on account of their particular coefficient of refraction. The silica-bodies are either approximately cubic or parallelopipedic or perfect casts of the cell-lumina, or more or less irregular and rarely quite solid, minute cavities appearing as pores or rents being the rule. Silicification of the cell-walls does not seem to occur, or only to a limited degree. The stomata possess semilunar guard-cells, flanked generally by very large subsidiary cells (Pl. 46. fig. 25), which are frequently perfectly filled up with silica. The whole epidermis, including the guard-cells of the stomata, is completely cuticularized.

Immediately below the epidermis, the tissue has a collenchymatic (Pl. 46. fig. 24) character. This zone is about 4–5 cell-layers deep, the cells gradually increasing inwards in size. They are tangentially slightly flattened and longest in the longitudinal axis of the fruit; they contain a considerable amount of plasma and chloroplasts, but little (the inner) or no starch. This collenchyma passes inward gradually into a parenchyma (Pl. 46. fig. 27) the cells of which are of very considerable dimensions, approximately isodiametric, pitted and filled with starch. This is present in ellipsoid or subglobose masses, composed of minute globose granules, 1–4 μ in diameter, and in isolated more or less ellipsoid granules of 6–8 μ in diameter. The compound starch-grains, however, break up very readily into their components. The only other contents are a very faint plasmatic wall-lining and a very small quantity of oil. The cell-walls are rather thick and swell very much in a diluted solution of potassium hydrate. The ordinary reagents for cellulose show that the walls of this parenchyma as well as those of the collenchyma are of pure cellulose, with the exception of a thin central lamella. Towards the inner surface of the pericarp the elements of the parenchyma (Pl. 46. fig. 29, *p.*) decrease rapidly in size, being at the same time tangentially slightly flattened, whilst the cell-walls exhibit the same character as in the outer parts. The innermost layer which borders immediately on the diaphragm, and represents the inner epidermis, is in no way differentiated from the small-celled tissue immediately outside it, except in so far as the lumina are still more reduced and often irregular, as if the cells had been exposed to unequal pressure. This small-celled inner zone as a rule contains starch only in the outer layers and in the shape of minute granules; otherwise the principal directly visible cell-contents are plasma and some oil.

The whole of the pericarp is traversed by vascular strands (Pl. 45. fig. 5) which, seen in transverse sections, appear arranged more or less concentrically, being most numerous towards the periphery. They are directed from the base of the fruit upwards, branching here and there but not frequently, and consist chiefly of cambiform tissue and fine strands of tracheids. Most of them must have been formed during the growth of the fruit, as they are much more numerous than in the ovary.

The ribs of the fruit, where present, exhibit no special characters in their structure, but it is probable that the formation of the collenchyma starts from them.

B. *The Diaphragm.*

In describing the development of the fruit, I pointed out that the diaphragm of the mature fruit represents the collapsed and crushed remains of the rudimentary endosperm which develops in the earlier stages of the young fruit. Seen in a transverse section under a low power it appears as a thin zone distinctly marked off towards the embryo, but less so towards the pericarp, from which it differs mainly in its greater density, resembling somewhat hardened jelly. Its thickness varies slightly in different parts, but without any definite relation to the orientation of the embryo, from 15 μ to 50 μ or more. It separates readily from the embryo except near the base, but is so firmly attached to the pericarp that it cannot be removed, unless it is soaked for some time in water, when it swells and may be pulled off in fragments. This lining often appears, where it is thinnest, even under a higher power, almost homogeneous (Pl. 46. fig. 29, *d.*), with tangential lines of less density and, in places, a delicate tangential striation. On the other hand, if we examine it where it is widest, distinct cell-lumina of usually tangential extension may be seen, at least in the part nearest to the pericarp. If these sections are, however, left soaking in water or a very dilute solution of hydrate of potassium, or in Eau de Javelle, the tissue becomes gradually loosened, and with the aid of needles it may be so expanded as to restore approximately the original shape of the cells (Pl. **46.** figs. 30, 31) constituting the tissue, which in this condition may measure as much as 0·75 mm. in diameter. This means that, in its crushed state, it was compressed to $\frac{1}{20}$ to $\frac{1}{50}$ of its original thickness. In expanding this tissue, it always struck me that the outer and middle strata yielded much more readily to the needle than the innermost, which often remained in their compressed condition. The cells of the outermost two or three strata are the smallest and nearly isodiametric. They contain the scanty remains of the plasmatic wall-lining and of the nucleus. Farther inwards the cells increase rapidly, with their greatest diameter in the direction of the radius. They are completely empty or contain the vacuolate skeleton of a nucleus. All the cells of this tissue possess extremely delicate walls giving typical cellulose reaction, and are destitute of pits or any other sculpturing. What appears at first glance as tangential striation is nothing but the delicate folding of the completely crushed radial walls, and corresponds to the equally delicate undulation they exhibit in transverse sections (Pl. **46.** fig. 32).

C. *The Embryo.*

The general structure of the embryo on the whole agrees with that of the typical grass fruit, with the exception of the enormous development of the scutellum, which either completely fills up the cavity of the pericarp or, towards the top, leaves a portion of it empty. We may distinguish the following parts in the embryo (Pl. **47.** figs. 36, 44, 51):—(1) the plumule; (2) the coleorrhiza with the primary and several secondary roots within it, the whole corresponding to the "radicle" of descriptive botany; (3) the curiously modified and enlarged scutellum; and (4) the remaining portion of the embryo, constituting the hypocotyl. The most striking feature of the embryo next to the scutellum is the curvature of the embryo, which is so strong that the inner faces of the plumule and the radicle are contiguous. This is unique in grasses, although an approach to it may be seen in the curved embryos of *Oryza* and *Leersia*. It is evidently due to this condition that no trace of an epiblast is seen. Its place would be the inner angle of the bend, where there is no room for such an organ. These being the main features of the embryo, I will now proceed to describe the different parts more in detail.

1. *The Plumule* (Pl. **45.** fig. 3, *pl.*; Pl. **47.** figs. 36–40, *col.*).—The plumule has the shape of a short, somewhat oblique cone, and consists of a coleoptile with a bud in its axil, and about seven distinct young leaves and the rather flat growing point. The coleoptil (Pl. **47.** figs. 44, 45) is open on the top and along a slit descending on the inner face which is contiguous with the radicle, the margins being minutely ciliate. According to Schlickum ("Morph. u. anat. Vergleich d. Keimpflanz. d. Monokotyl.," in Bibl. Botan. vi. (1896) p. 68), the coleoptile of the grasses differs essentially from the leaves following it in the absence of stomata and the presence of only two vascular bundles. This is not the case in *Melocanna*, the coleoptile (Pl. **47.** fig. 46) in these respects entirely resembling the leaves nearest to it. It possesses not only stomata and numerous vascular bundles, of which about 17–19 are of the first order, but the structure of the outer epidermis is much more complicated than might be expected.

For the epidermis (Pl. 47. fig. 55), besides having stomata, is differentiated into long and short cells (“Kurzzellen,” Pfitzer) and two kinds of hairs, viz., fine, stiff-pointed, 1-celled bristles, and smaller, thin-walled, 2–3-celled, obtuse, club-shaped hairs, which are usually bent above the basal cell so as to lie more or less on the epidermis, corresponding to the “Winkelhaare” of Grobb (“Anat. d. Epiderm. Gramineenblätt.,” in Bibl. Bot. vii. p. 20). As already mentioned, the coleoptile always bears a small bud (Pl. 45. fig. 23; Pl. 47. figs. 46–48, *b.*) with several distinct leaf-primordia in its axil, either opposite the radicle or more frequently slightly lateral. The first leaf after the coleoptile (fig. 46, 1.) is exactly opposite to it, flattened and slightly 2-keeled on the back, not unlike an ordinary dorsal bract (“adossirtes Vorblatt,” Eichler), a condition evidently due to the pressure of the radicle, and disappearing as soon as the leaf grows beyond it in the course of germination. Like the coleoptile, the first leaf possesses numerous vascular bundles. The second leaf is so placed that its median plane cuts that of the coleoptile and first leaf at an angle of 30°; the third leaf is approximately opposite the second. The fourth diverges from the second by about 60°, and its median plane is therefore at a right angle to that of the coleoptile. The following leaves diverge approximately at an angle of 180° from the preceding leaf. The median plane of the coleoptile and the first leaf coincide therefore with that of the embryo, whilst the fourth and the following leaves of the plumule are placed at right angles to it, and the second and third leaves are in an intermediate position. I may add that the second leaf overlaps the third very distinctly on the outer side, whilst it is, though slightly, overlapped by it on the inner side (*i. e.*, the side towards the radicle). In the following leaves the overlapping is quite normal.

2. *The Radicle* (Pl. 45. fig. 3, *r.*; Pl. 47. figs. 36–43, *rad.*).—Like the plumule, the radicle has the shape of an oblique cone, but it is rather smaller. I have already mentioned that it consists, as is generally the case in Gramineæ, of a coleorrhiza, which is very large, a primary root (Pl. 47. fig. 46, *r.* I.), and a few secondary roots (Pl. 47. figs. 47, 51), which are arranged almost concentrically, and start at a level which corresponds to a cross-section from the inner angle of the embryo to the junction of scutellum and coleorrhiza on the opposite side. There is only one point in the structure of the radicle to which I wish to draw attention. As stated above, there is no epiblast in *Melocanna*, but on the outer side (*i. e.*, the side opposite to that where we would look for the epiblast) I once noticed a small scale (Pl. 47. figs. 39 *ex.*, 40) of the shape and structure of an epiblast, whilst in another case only an irregular swelling was perceptible. In a third seed I found a short obtuse protuberance placed somewhat laterally and projecting downwards. At first I thought it might correspond to some secondary root, but, in dissecting it, I found it to consist of the same parenchyma as the coleorrhiza, and that it was not correlated to any secondary root which was then discernible. Another peculiarity of the coleorrhiza is the presence of very fine though comparatively deep furrows (Pl. 47. figs. 39, 53), extending longitudinally on the upper and outer side. There is apparently no definite rule as to their number and position, and, so far as I was able to see, no distinct correlation to anything in the internal

structure of the radicle or of the scutellum up to which they may continue. I have no explanation to offer at present with respect to these appendages and furrows, but they seem to point to a certain plasticity of the coleorrhiza, and throw, perhaps, some light on the nature of the epiblast as an appendage of the coleorrhiza.

3. *The Scutellum.*—The scutellum (Pl. 45. figs. 3, 5, 7, *sc.*; Pl. 47. figs. 36–38, 51) is a large fleshy body, 20 to almost 40 mm. long, and 12 to 16 mm. in diameter where widest. It is oblong-ellipsoid, terete or slightly compressed at a right angle to the median plane. Its surface may be regularly curved, or slightly constricted about the middle, or faintly indented on one side. This indentation (Pl. 47. figs. 36, 37) corresponds to the upper end of the ovarial cavity, which in the mature seed is completely obliterated, but leaves occasionally traces in the moulding of the scutellum which fills up the cavity. At the base, the scutellum is slightly produced into a rim, so as to cover a part of the radicle and the plumule. The rim (Pl. 47. figs. 36, 37, 38, 40) may be two-lipped, as shown in Pl. 47. figs. 36 & 40, or it may be interrupted where the coleorrhiza scale overlaps the base of the scutellum (fig. 40). The epidermis of the scutellum is developed almost entirely as haustorial epithelium (Pl. 46. fig. 29, *epth.*), and agrees exactly with that of *Triticum* and other grasses. The cells are about twice as high as wide, thin-walled, not at all cuticularized, and full of plasma and proteids. Their outer walls, as a rule, bulge very little, although sometimes cells, or groups of cells, may be seen projecting beyond their neighbours; but they do not seem to grow out into papillæ, as is the case in certain other grasses. An exception to this epithelial modification of the epidermis, however, is to be found at the very base of the scutellum, mainly where it overlies the embryo proper. Here, over the edge as well as on the inner side of the reflexed rim, the epidermal cells are comparatively shallow, their outer walls thickened and covered by a delicate cuticle. They contain plasma, but only in moderate quantities. The bulk of the tissue of the scutellum consists of thin-walled parenchyma (Pl. 46. fig. 35) with plenty of interstices, the cells decreasing near the periphery. It is only in the basal rim that the parenchyma assumes a collenchymatic character. The cells are pitted, the pits being circular or oblong, and, owing to the thinness of the walls, of course very shallow. The cell-walls are of pure cellulose. The scutellum is traversed throughout its length and breadth by numerous vascular strands (Pl. 45. fig. 5, Pl. 47. fig. 51), which, entering at its base from the axis, spread like the halms of a loose sheaf, branching freely towards the periphery, and terminating in innumerable branchlets close to the epithelial surface, separated from it by not more than 2–3 layers of small parenchyma. They consist mainly of a delicate cambiform tissue, with slender strands of tracheids (Pl. 46. figs. 33, 34), and appear to possess no solid contents with the exception of some scanty starch in the outer parts. The tracheids disappear just below the ends of the strands, which terminate with a cap of cambiform tissue.

The Hypocotyl.—If we remove the radicle, plumule, and scutellum from the embryo, a portion of the latter is left which has approximately the shape of a piece cut out of a cylinder with an elliptical base by two oblique sections intersecting at an angle of 90°–100° just within one of the poles of the short axis. The line of intersection would correspond to the inner angle of the embryo proper, the broad back of the cylinder fragment to the ideal contact-plane with the scutellum, whilst only a small portion of the cylinder surface, a triangular piece on each side, is left exposed; but even of these flanks, a considerable portion or the whole is overlapped by the deflexed rim of the scutellum. The epidermis of the hypocotyl resembles that of this rim. Below it there is parenchyma containing starch in quantities increasing in the direction towards the scutellum. The centre of the hypocotyl is, however, occupied by a plate (Pl. 47. figs. 40, 48, 51) consisting of a perfect tangle of vascular strands recalling the structure of mazerwood (Pl. 47. figs. 52, 53). This plate extends close to the outer base of the coleoptile on one side, and to near the root initials on the other. It is convex and well-defined towards the scutellum, but breaks up towards the plumule into numerous procambial strands going to the coleoptile and the leaf-primordia. Another set of vascular strands enters the scutellum, starting abruptly out of the dorsal surface of the plate. The structure of the strands is on the whole plain enough (Pl. 47. fig. 54). They consist of procambium with usually simple threads of tracheids. Only those which are situated towards the ends of the plate, that is near the outer base of the coleoptile and the root-primordia, show a higher differentiation, containing rows of wide cells with grate-like perforations (a kind of short-jointed vessels), thin-walled parenchyma more or less rich in starch, and subprosenchymatic portions with lignified thick walls and full of starch, and finally a slender strand of delicate phloem. The space between the tangled strands of the axil plate is occupied by parenchyma containing starch. This concludes the description of the internal structure of the fruit.

VII. Germination.

I have already quoted Kurz's and Robinson's remarks concerning the germination of the *Melocanna* fruit on the tree (p. 402). There is no more recent account of this phenomenon, which is, with the exception of *Melocalamus*, apparently quite unique among grasses; their statements, more especially Robinson's, are, however, so precise and definite, that there can be no doubt that we have in *Melocanna* a remarkable example of vivipary. All the fruits of *Melocanna* which were at my disposal, with the exception of those from the Garo Hills, possessed a well-developed embryo, and in about half of them the radicle and plumule had already pierced the pericarp, the former having in several cases produced a bundle of secondary roots. But no fruit was gone so far as some observed by Kurz, who says of *Melocanna bambusoides* ('Indian Forester,' i. p. 268): "the fruits drop from the plant after they have made shoots some 6 inches long."

The first outward sign of beginning germination is that the embryotegium turns brown or black, and is lifted up like a lid by the tips of the plumule and radicle which appear simultaneously. They soon push the embryotegium aside; but it may still remain attached to the fruit for some time. Then the plumule (Pl. 45. figs. 6, 7; Pl. 47. figs. 41, 51) grows out; its young leaves burst through the coleoptile, and push out like the joints of a telescope. A small shoot is formed, densely covered by firm, rather thick, puberulous cataphylls. As already remarked, this shoot may attain a length of 15 cm. before the fruit falls; but, as it seems, it develops scarcely any blades for some time, as Kurz says ('Indian Forester,' i. p. 268) "these shoots attained a height of 15 to 16 inches after only ten days that they were planted out in the ground, but had thrown out only two leaves:" a statement which is borne out by a drawing of a seedling in Gamble's herbarium.

Simultaneously with the plumule, the root-system develops. The primary and the secondary roots break through the coleorrhiza and grow rapidly into a bundle of thick root-fibres, among which the primary root is not readily distinguished, if it does not altogether die early, as seems frequently to be the case. Plumule and roots thus quickly outgrow the depression at the fruit-base from where they started, diverging at the same time. The scutellum, however, remains enclosed in the cavity of the pericarp, a neck being formed by intercalary growth at the base of the scutellum. This neck may attain a length of almost 10 mm. with a diameter of 4–5 mm. (Pl. **45.** fig. 7; Pl. **47.** figs. 41, 51). Longitudinal sections through a germinating fruit show this neck clearly, but they scarcely reveal any other macroscopically visible change in the scutellum and the pericarp, except in so far as in some cases certain peripheral portions of the pericarp, chiefly in the upper part, appear brown, a sign of decay. The microscopical examination of the pericarp, however, shows that the macroscopic changes in the germinating fruit are accompanied by the gradual exhaustion of the pericarp. The first sign of this exhaustion is the breaking up of the compound starch-grains, after which the starch disappears gradually. At the same time the outer lamellæ of the thick cell-walls of the parenchyma are dissolved, the walls appearing corroded all over, so that finally, in places, not much more is left of them than the central lamella. Whilst the depletion of the pericarp had already gone far in some of the fruits which were at my disposal, there was no change yet noticeable in the scutellum. This organ evidently remains active as long as there is any possibility of drawing on the pericarp, and its own exhaustion sets in only after the depletion of the pericarp.

Kurz's and Robinson's accounts of the germination of the *Melocanna* fruits on the tree (see p. 402) give the impression as if this condition was the normal state. No doubt it is of frequent occurrence, and may be the rule. Still the structure of the fruit is such as to justify the assumption that the young plant may just as well establish itself in the case of the fruit falling before germination has set in. In fact, Gamble states ('Indian Bambuseæ,' p. 120) that he grew young *Melocanna* plants from fruits which had not yet germinated when they were put in the soil. Nor should it be overlooked that the chances of injury to the shoot of germinating fruits when falling from a height of 40–70 feet must be very great, even if they fall into very soft soil. Unfortunately we know nothing as to the condition of the *Melocanna* forest at the critical time when its restocking takes place, nor have I been able to ascertain in what season the fall of the fruit occurs. So much, however, seems to be certain that the fruit once detached from the mother-plant does not stand a long delay, at any rate under the conditions to which it would be naturally exposed on the ground of the forest. There is apparently nothing in its structure to prepare it for a period of rest and to protect it during that state. On the contrary, everything points to the immediate transition from maturation to germination, which is characteristic of all viviparous plants. It may be asked in how far the term "vivipary" is applicable to *Melocanna bambusoides*. Of course if we confine it to those cases where the embryo pierces the fruit whilst it is still in connection with the mother-plant, we could only speak of this bamboo as "facultatively viviparous;" but this does not seem to be correct. Where the fruit of *Melocanna* agrees with other fruits commonly admitted as viviparous is in the development of the embryo outside the embryo-sac and at the expense of the mother-plant. Whether the separation from the latter occurs, in *Melocanna*, before or after the actual piercing of the pericarp is not much more than an accident, possibly dependent on the weight of the fruit and the tensile strength of the fruit-stalk, or external factors, as storm or rain. The uninterrupted development of the embryo is practically safeguarded in both cases. The remarkable circumstance, however, in which this instance of vivipary differs from all the others known so far, is the ample supply of reserve food with which the seedling starts its independent life.

VIII. Conclusion.

I will now try to summarize the results of my investigations into the structure and the germination of the fruit of *Melocanna*, mainly with respect to the points in which it deviates from the typical grass fruit, and to examine how far these structural modifications are correlated with functional differences.

The ordinary grass fruit is small, indeed very small, compared with the fruit of *Melocanna*. The pericarp is dead; its functions are essentially mechanical, and it is accordingly developed as a thin crustaceous or skinny and dry shell which in the course of development has become adnate to the seed. The testa is a delicate and often obscure membrane, likewise dead, which is fused to the pericarp, and if it has any function worth mentioning it goes to strengthen the pericarp. The reserve materials required for the germinating embryo are deposited in the endosperm, which forms the bulk of the fruit. The embryo itself is usually small, although already well differentiated and free of starch, the scutellum acting merely as sucker on the endosperm. Maturity attained, the fruit separates from the mother-plant, and the embryo starts an independent life after a shorter or longer period of rest. All this is very different here. In *Melocanna* the pericarp attains relatively enormous proportions, remains fleshy, although rather hard and tough, and it has an active and very important share in the metabolism of the maturing and germinating fruit. Its functions are, in the first place, those of an ample reserve depot, the reserves consisting of the cell-contents as well as of the cell-walls. A well-developed system of vascular strands, spread through the pericarp in concentric arrangement, serves to convey and distribute the materials which go to build up, feed, and fill the growing fruit, and possibly also to supply the embryo with water if the fruit germinates whilst still on the tree. The strands enter the fruit at the base, where it is attached to the rhachilla that acts as fruit-stalk. This is, considering the size of the fruit and the amount of the nutritive matter and water which have to pass it, remarkably slender (Pl. 45. fig. 4, *rh.*). It measures not more than 0·4–0·5 mm.^{2} in cross-section, of which more than one half goes to the dry parenchymatic cortex, whilst the stereome and mestome of the central cylinder are approximately in the proportion of 3 : 1 (Pl. 47. fig. 57)*. It is true a portion of the products of assimilation deposited in the fruit has, no doubt, originated in the chlorophyll of the collenchyma of the pericarp; but it is not probable that this relieves the strain on the mother-plant as the main source of supply to any considerable extent, and the water in any case has to come entirely through the narrow channels of the stalk. The complete cuticularization and the thickening of the epidermis as well as its silicification must thus be a great aid for the plant in economizing the water-supply by reducing the transpiration to a minimum, at the same time contributing to the efficiency of the epidermis as a mechanical tissue. Mechanical is also the function of the collenchyma in so far as it provides for the necessary rigidity of the growing fruit, and in the mature state adds to the strength of the pericarp, resulting from the thick cell-walls of its parenchyma. Thus the deposition of a portion of the reserves as cellulose has incidentally a considerable mechanical effect in the direction of compressive strength, which is very important considering the height from which the fruits fall. Otherwise, however, there is little in the pericarp to protect it and the enclosed seed for any length of time from the attacks of the animal and vegetable world and destructive atmospheric influences. The *Melocanna* fruit is evidently not built for a lengthy period of rest. To speak of the seed, we have seen that it is naked. In fact, the term "seed," in the usual sense, is scarcely applicable to it. There is, *ab initio*, no integument to form a testa, and the free ovule-wall corresponds to so small a fraction of the full-grown embryo-sac, and is lost so completely in the pericarp, that any function the testa has in the ordinary grass-seed, be it in the nascent or the final state, must devolve on the pericarp. So far as they are purely mechanical they are, in the presence of the powerful pericarp and the absence of a resting period, certainly a negligible quantity. On the other hand, if the nascent testa of the typical caryopsis, that is the inner integument of the maturing seed, acts as passage or transfusion tissue in the sense of Tschirch's 'Nährschicht'†, this function is taken over by the innermost layers of the pericarp, which supply immediately the maturing seed with water and nutrient matter. The typical store-organ of the fruit of the Gramineæ is the endosperm. In *Melocanna* endosperm is formed, but its formation does not go much beyond the initial stages. It is soon exhausted, collapses, and is finally crushed into an apparently structureless film, wedged in between pericarp and scutellum. To compensate the loss of the endosperm, the storage of nutrient matter is shifted on partly to the pericarp, partly to the scutellum, and cellulose has been added in the former to the usual reserve materials of the grass-seed. Curiously enough, the normal disposition of proteids and starch in the grass endosperm, namely, proteids in a peripheral layer and starch in the remainder, has found a parallel in the scutellum of *Melocanna*. But "obliterated" as the endosperm may be, and reduced to the state of a diaphragm, it is certainly not without its share in the economy of the *Melocanna* fruit. Sachs, in his paper on the germination of the grasses ("Zur Entwicklungsgeschichte der Gräser," Botan. Zeit. xx. 1862, p. 146) pointed to the presence in certain grasses of an obliterated tissue between the starch containing endosperm and the scutellum, and he showed that it was a depleted portion of the endosperm. Tschirch called this tissue "Quellschicht" (Tschirch & Oesterle, Anatom. Atlas, p. 184, Q in fig. 17 of pl. 42), a name which appears to me not well chosen, as it is neither analogous nor homologous to what German botanists ordinarily call "Quellschicht," *i. e.*, the mucilaginous layers in the testa of seeds, e. g. *Linum* or *Salvia*. As this obliterated tissue seems to be a rather common occurrence in seeds also outside the order Gramineæ, a more appropriate term is desirable, and it seems to me that this tissue might be conveniently designated as "diaphragm." It is clear that in seeds possessing such a "diaphragm" the food reserves of the endosperm have to pass the diaphragm in solution, but its actual functions are still obscure. Possibly it acts as a kind of filter. In a way analogous to that described by Sachs, the diaphragm of *Melocanna* is interposed between the store-organ (or rather one of the store-organs) and the scutellum, and its functions are no doubt also similar.

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* The dimensions measured in a typical case were:—cross-section, just below the flowering glume, 0·44 mm.^{2}; cortex 0·232 mm.^{2}; central cylinder 0·206 mm.^{2}; stereome 0·149 mm.^{2}; mestome 0·0574 mm.^{2} The fruit was fully developed and of average size

† See Tschirch, 'Angewandte Pflanzenanatomie,' p. 459; and Holfert, "Nährschicht der Samenschalen," in Flora, 1890, pp. 279–313.

Although the scutellum has replaced the endosperm to some extent, it has not lost its original character as haustorium. It has rather increased in bulk and sucking surface, and become equipped with a highly developed system of mestome strands for the conveyance of the reserve materials to the fast growing embryo. In accordance, however, with the changed structure of the *Melocanna* fruit, it directs its energies towards the starch-filled pericarp, inducing there those chemical changes which result in the break-up and the disappearance of the starch, the greater portion of the cell-walls, and the remainder of the cell-contents generally. The carbohydrates pass through the inner cell-layers of the pericarp and the diaphragm most likely as glucose, the proteids as asparagine. The presence of the latter in the diaphragm and in the small cavity left occasionally between it and the scutellum was strikingly demonstrated in some fruits which had been sent in alcohol and had just started germinating when collected. In them the asparagine had crystallized, the crystals being either embedded in the diaphragm or attached to its inner surface, or sometimes to the surface of the scutellum. They were fairly numerous and up to 2 mm. long. Those which were found on the scutellum could easily be taken up, otherwise they had to be scraped or pulled from the diaphragm. The occurrence of the crystals suggested, under the circumstances, at once the presence of asparagine, and their solubility in water, as well as their behaviour when heated, seemed to confirm my assumption. To make quite sure, I sent a quantity of crystals to my friend Professor Hans Molisch, of Prague. He subjected them to further tests with the same result, and, finally, Mr. G. F. H. Smith, of the Mineralogical Department of the British Museum, determined them crystallographically as levo-asparagine.

We have still to consider the embryo proper (the embryo minus the scutellum). It can scarcely be said that it is more differentiated or more advanced in development before it leaves the fruit than the embryos of a good many typical grasses; but it is much larger and possesses a more highly-developed vascular system. It differs further in its pronounced curvature, which results in the immediate juxtaposition of plumule and radicle, and in the similarity of the coleoptile and the leaves following it. The increased size of the embryo corresponds evidently to the increased bulk of the fruit, whilst both determine the copious supply with vascular strands. As to the curious curvature of the embryo, it appears to be connected with its downward movement in the growing fruit, from the point of origin in the interior to its final external position. By curving in this way it offers the minimum of surface to the tissue which is to be displaced, securing at the same time the simultaneous egression of radicle and plumule when germination sets in. The unusual structure of the coleoptile might similarly be explained by its peculiar function as the first of a succession of cataphylls which cover the axis of the seedling much as the sheaths, or "imperfect leaves," of the stolon-shoots cover and protect their axes.

Conditions as to which we have nothing to proffer but conjectures have so modified the evolution of *Melocanna* that its fruit has become viviparous. We know practically nothing about the ecology of the *Melocanna* forest; but so much is clear, that the immediate transition from maturation to germination and the particular fitness and readiness of the embryo plant to establish itself—conditions implied in vivipary—must give the seedlings of *Melocanna* a certain superiority in the struggle with the numerous intruders which, in a tropical country full of conditions favourable for plant life, are sure to invade the ground as soon as the *Melocanna* jungle is fallow and dead. Vivipary in itself does not, of course, necessarily mean a large seed or fruit, but if we consider that the seedling of *Melocanna* attains a considerable size before it forms perfect leaves ready to assimilate, we shall understand why they are, in addition to their vivipary, so abundantly supplied with reserve food. All this necessarily means a large fruit, but also an increased surface for the scutellum, as the organ which induces the solution of the stored nutrient matter and its transmission to the growing parts; but increased surface is bound up with the development of a bulky body, of which only a limited portion can be utilized for the formation of vascular strands, the channels of building matter and water transport. The rest will be fundamental tissue, and it is only an instance of economy if we find in *Melocanna* this tissue acting as store-tissue in addition to the much ampler depot formed of the pericarp. The absence of a period of rest, and the consequent uselessness of a protective fruit- or seed-shell, made the pericarp available for the storage of the reserve materials coming from the mother-plant or in part formed almost *in situ*. The same reasons, if I may say so, allowed the plant to dispense with the testa (generally prone to reduction in Gramineæ); and affecting still earlier phases in the ontogeny of the seed, they led to the suppression of the integument and the general reduction of the ovule. Hence the naked ovule and, at the other end of the line of development, the naked seed, if "seed" we may call it. Endosperm is still formed; but deprived of its normal function it collapses early, its empty crushed tissues acting as a "diaphragm" between the pericarp (to some extent the physiological equivalent of the endosperm of the typical grass seed) and the haustorial epithel of the scutellum. In this way, we may imagine, the *Melocanna* seed has become endospermless or "ex-albuminous." With the growth of the rudimentary ovule, as a distinct entity within the fruit, soon ceasing, the embryo-sac develops outside the ovarial cavity in the body of the ovary. It retains, however, only the scutellum, whilst plumule and radicle at an early stage burst its bonds and push their way to the fruit-base. Thus we have in *Melocanna* a case where deep-going structural modifications and a corresponding transference of functions have taken place in the evolution of a most essential organ, otherwise so uniform in the order, with the result of securing under very different conditions that complete harmony in the economy of the organism which is the fundament of its existence.

It will be asked what light the structure of the *Melocanna* seed throws on that much discussed question of the morphological value of the scutellum, the coleoptile, and the epiblast. Highly specialized types, like *Melocanna*, rarely help us in the elucidation of obscure homologies. In this case, it is true, the differentiation of the embryo was little affected by the great modifications which the *Melocanna* fruit has undergone; but if they have not obscured or suppressed any of the essential features of the grass embryo, they have also not brought to light new traits either to confirm or to refute Schlickum's and Goebel's conception of the grass embryo, which, to my mind, is the only one that is really rational if we insist on reducing the monocotyledonous embryo to one definite type.

EXPLANATION OF THE PLATES.

PLATE 45.

Fig. 1. Mature fruit, seen in the position as it hangs on the tree: *et.*=embryotegium. ($\frac{9}{10}$.)

2. Mature fruit, side view: *lr.*=lateral ridge; *vr.*=ventral ridge. ($\frac{9}{10}$.)

3. The same, in longitudinal section: *p.*=pericarp; *d.*=diaphragm; *sc.*=scutellum; *et.*=embryotegium; *pl.*=plumule; *r.*=radicle. ($\frac{9}{10}$.)

4. Mature fruit, from below: *pa.*=palea; *va.*=valve; *rh.*=rhachilla (fruit-stalk). ($\frac{9}{10}$.)

5. The same, in cross-section: letters as in fig. 3. ($\frac{9}{10}$.)

6. Germinating fruit. ($\frac{9}{10}$.)

7. The same, in longitudinal section, roots cut: letters as in fig. 3. ($\frac{9}{10}$.)

8. Young hermaphrodite flower, front view: *pa.*=palea; *l.*=lodicule; *st.*=stamens; *pi.*=pistil. (4×.)

9. The same, with the palea and stamens removed, back view: *rh.*=rhachilla (continuation): *l.* and *pi.* as in fig. 8. (4×.)

10. Mature female flower with barren stamens, no lodicules. (4×.)

Fig. 11. Fertilized ovary with palea and rhachilla continuation, side view : *pa.*=palea ; *rh.*=rhachilla. (4 × .)

12. Lower part of a fertilized pistil in longitudinal section : *rh.*=rhachilla continuation ; *pa.*=palea ; *fil.*=filament ; *o.*=ovule ; *es.*=embryo-sac (indicated by the dotted line). (16 × .)

13. Fertilized ovary in cross-section (spirit-material) : *vr.*=ventral ridge, opposite the palea ; *oc.*=ovarial cavity ; *o.*=ovule ; *es.*=embryo-sac. (27 × .)

14. Fertilized ovule (from fig. 13), more magnified : *oc.*=ovarial cavity ; *ow.*=ovary-wall, outer layers (*) staining yellow with Schultz's solution, inner layers (**) staining blue ; *es.*= embryo-sac. (200 × .)

15. Fertilized ovary in cross-section from herbarium material, microtome section, made by Mr. Boodle : letters as in fig. 13. (27 × .)

16. Barren fruit, in longitudinal section, at a right angle to the median plane : *es.*=embryo-sac ; *d.*=diaphragm ; *oc.**=marking indicating the position of the obliterated ovarial cavity. ($\frac{9}{10}$.)

17. The same, in cross-section : fig. as in 16. ($\frac{9}{10}$.)

18. Another barren fruit, in longitudinal section in the median plane : *oc.**=obliterated ovarial cavity ; *ao.*=apex of ovule ; *es.*=embryo-sac. ($\frac{9}{10}$.)

19. Lower portion of ovule (from fig. 18) : letters as in fig. 18. (4 × .)

20. Part of the cross-section represented in fig. 17 : *p.*=pericarp ; *oc.**=obliterated ovarial cavity, filled with a structureless mass ; *end.*=endosperm, almost collapsed ; *ow.*=ovary-wall. (27 × .)

21. Part of the same, more magnified : letters as in fig. 20. (160 × .)

22. Lower part of a semi-mature fruit : *p.*=pericarp, at * spongy and collapsing ; *es.*=embryo-sac ; *end.*=endosperm, at ** stretching across the cavity, indicating the level at which the embryo formed originally ; the apex of the ovule has quite disappeared : *e.*=embryo. (3 × .)

23. Embryo of the fruit represented in fig. 22 : *co.*=coleoptile with a bud (*b.*) in its axil, its base covered on one side by the projecting rim of the scutellum (*sc.*), on the other by the radicle (*r.*) ; *sr.*=secondary root initial. (16 × .)

PLATE 46.

Fig. 24. Epidermis and collenchyma of the pericarp : *chl.*=chloroplasts ; *am.*=starch. (400 × .)

25. Epidermis (surface view) with stoma : silicified guard-cells. (400 × .)

26. Epidermis treated with Eau de Javelle and embedded in clove-oil : only the silicified cells are visible. (400 × .)

27. Parenchyma from the middle of the pericarp, before germination ; the contents of one cell only are shown : *amc.*=compound starch-grains ; *ams.*=simple starch-grains. (400 × .)

28. Parenchyma from the middle of the pericarp, germination advanced ; cell-walls partly dissolved and corroded. (400 × .)

29. Innermost part of the pericarp, diaphragm, and outer part of the scutellum : *p.*=pericarp ; *d.*=diaphragm ; *sc.*=scutellum ; *epth.*=epithelium ; *am.*=starch. (400 × .)

30. Outer part of the diaphragm (obliterated endosperm), expanded. (400 × .)

31. Portions of the inner cells of the diaphragm, expanded, from a semi-mature fruit with transitory starch. (400 × .)

32. One of the crushed inner cells of the diaphragm, imperfectly expanded. (400 × .)

33. Vascular strand of the scutellum, in cross-section : *ca.*=cambiform ; *tr.*=tracheids. (× 400.)

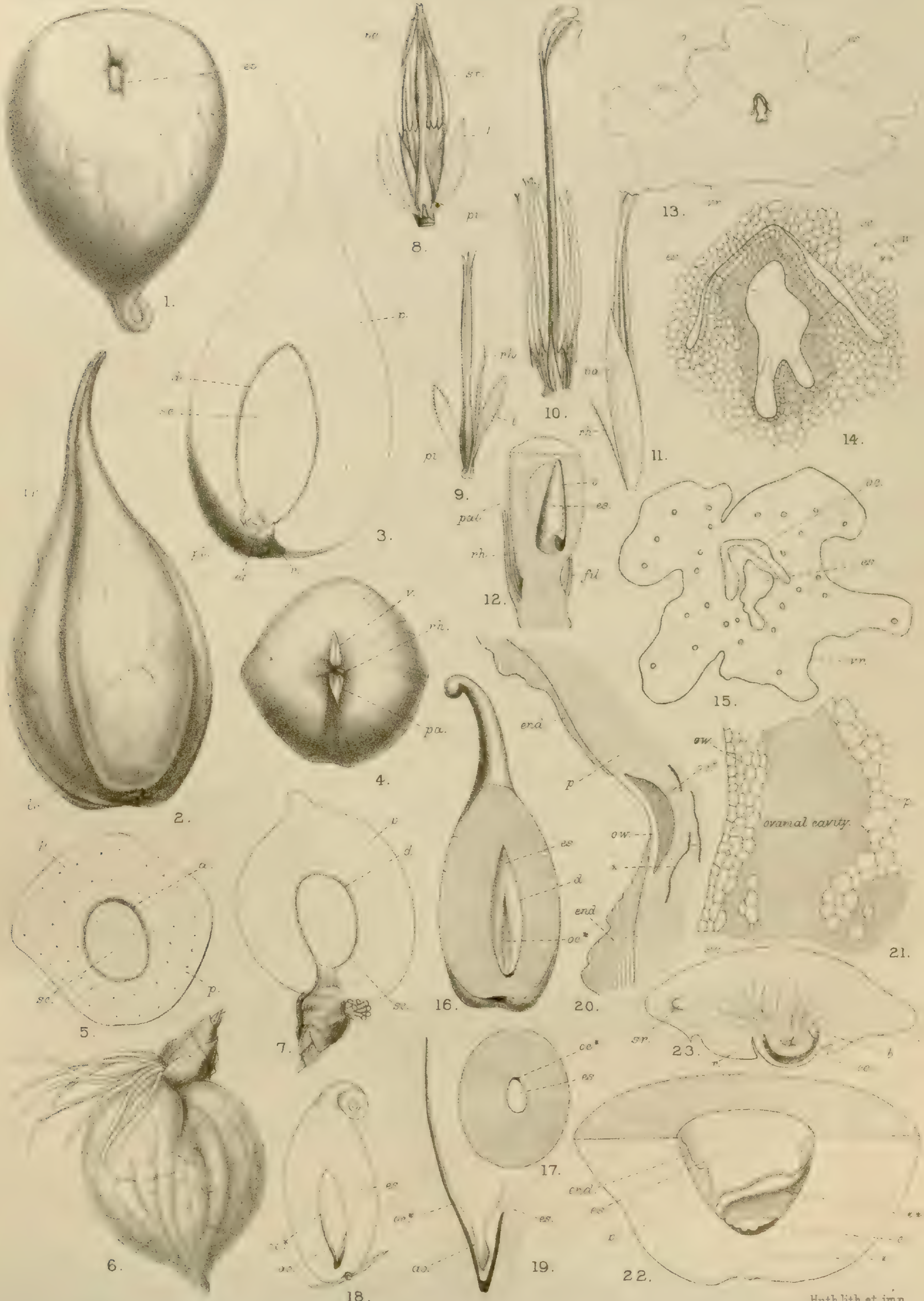
34. Vascular strand of the scutellum, near the surface, somewhat obliquely cut : letters as in fig. 33. (400 × .)

35. Parenchyma from the centre of the scutellum : *am.*=starch ; *pi.*=pits. (400 × .)

Plate 47.

Fig. 36. Complete embryo: *col.* = coleoptile (plumule); *rad.* = radicle; at * ridge corresponding to the obliterated ovarial cavity. ($\frac{9}{10}$.)

37. The same, seen from the side: letters as in fig. 36. ($\frac{9}{10}$.)
38. The same, seen from below: letters as in fig. 36. (2 × .)
39. Plumule and radicle of an embryo with the overlapping rim of the scutellum removed: *e.r.* = epiblastoid excrescence of the coleorrhiza; other letters as in fig. 36. (4 × .)
40. The same, in longitudinal section, but the embryo still enclosed in the pericarp: *p.* = pericarp; *et.* = embryotegium; *col.* = coleoptile; *r.* = radicle. Above the plumule the central plate of strands, sending out diverging strands into the scutellum; in the axil of the coleoptile a small fragment of the base of a bud. (4 × .)
41. Embryo in the first stage of germination: *scn.* = neck of the scutellum; other letters as in fig. 36. ($\frac{9}{10}$.)
42. Plumule and radicle of the same embryo. (4 × .)
43. The same, seen from the other side: letters as in fig. 36. (4 × .)
44. Plumule seen from the inner side, radicle removed: *co.* = coleoptile; *rad.* = base of radicle. (4 × .)
45. Top of the coleoptile of the same, showing the ciliolate margins. (4 × .)
46. Cross-section through a plumule and radicle: *b.* = bud; I–VII = leaves of the plumule enveloped by the coleoptile; *coz.* = coleorrhiza; *r.* I = primary root. (16 × .)
47. Cross-section through the base of the plumule and radicle: *b.* = bud; *co.* = coleoptile; I = part of the first leaf of the plumule. (4 × .)
48. Cross-section through the embryo near the base of the neck; strand-plate of the hypocotyl shaded: letters as in fig. 47. (4 × .)
49. Cross-section through the base of the neck: *p.* = a fragment of the pericarp; the dots indicate the vascular strands going to the scutellum. (4 × .)
50. Cross-section through the narrowest part of the neck. (4 × .)
51. Longitudinal section through a germinating embryo; most of the inner leaves of the plumule removed, roots cut. (2 × .)
52. Longitudinal section through the upper part of the axil plate of the hypocotyl; the dark portions indicate parenchyma containing starch. (27 × .)
53. A portion of the cross-section represented in fig. 48, showing a part of the axil plate of the hypocotyl in tangential section; on the right-hand side furrows descending towards the radicle. (16 × .)
54. Procambial strands, from the axil plate, in cross-section: *am.* = starch containing parenchyma, corresponding to the shaded parts in fig. 52. (200 × .)
55. Epidermis of coleoptile with a bristle and a "Winkelhaar" (surface view). (400 × .)
56. Epidermis of the neck of a germinating embryo, in longitudinal section. (400 × .)
57. Cross-section of a fruit-stalk (rhachilla), close below the valve (floral glume): *cort.* = cortex; *mest.* = mestome strands; *ster.* = stereome. (55 × .)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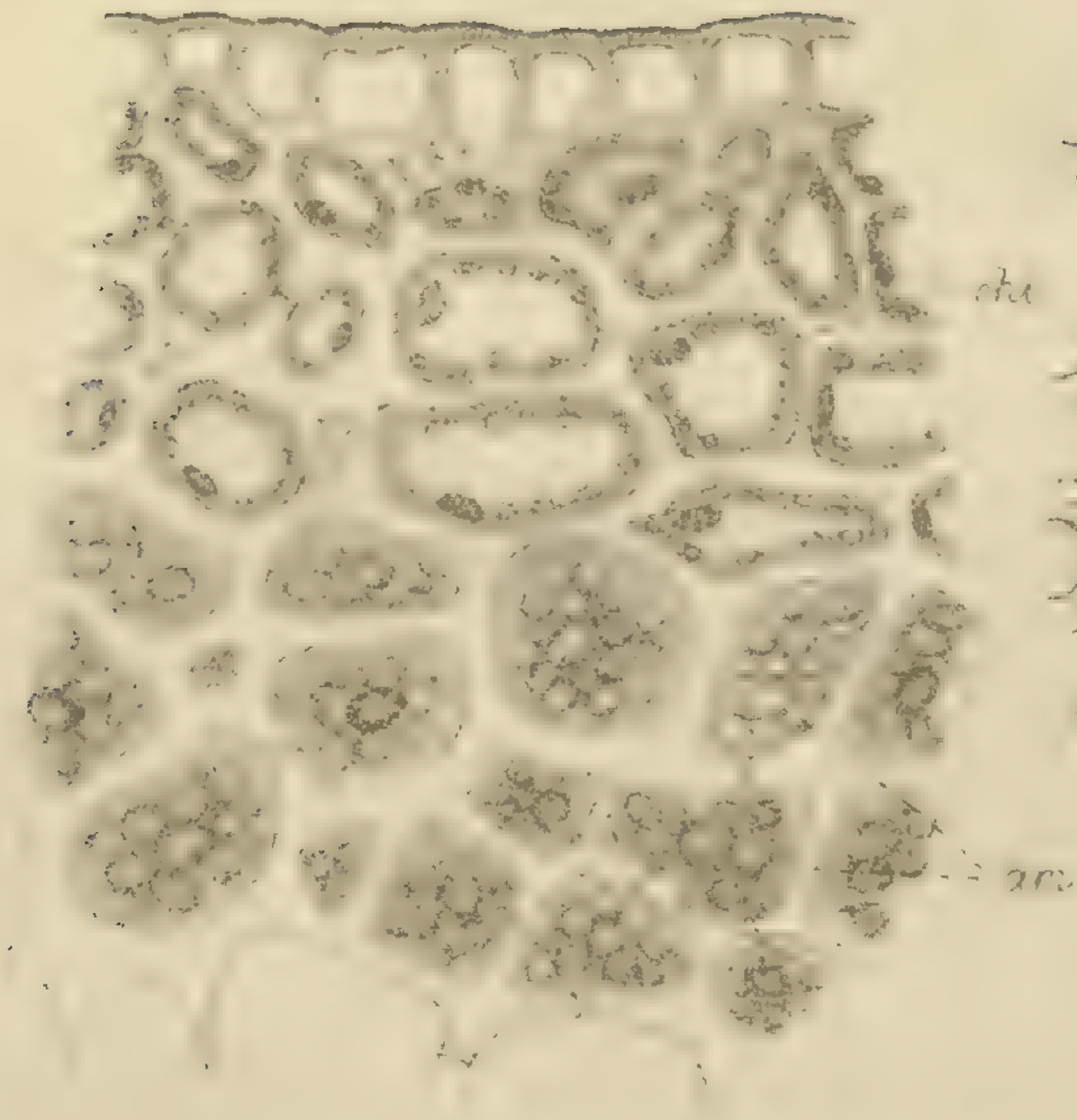

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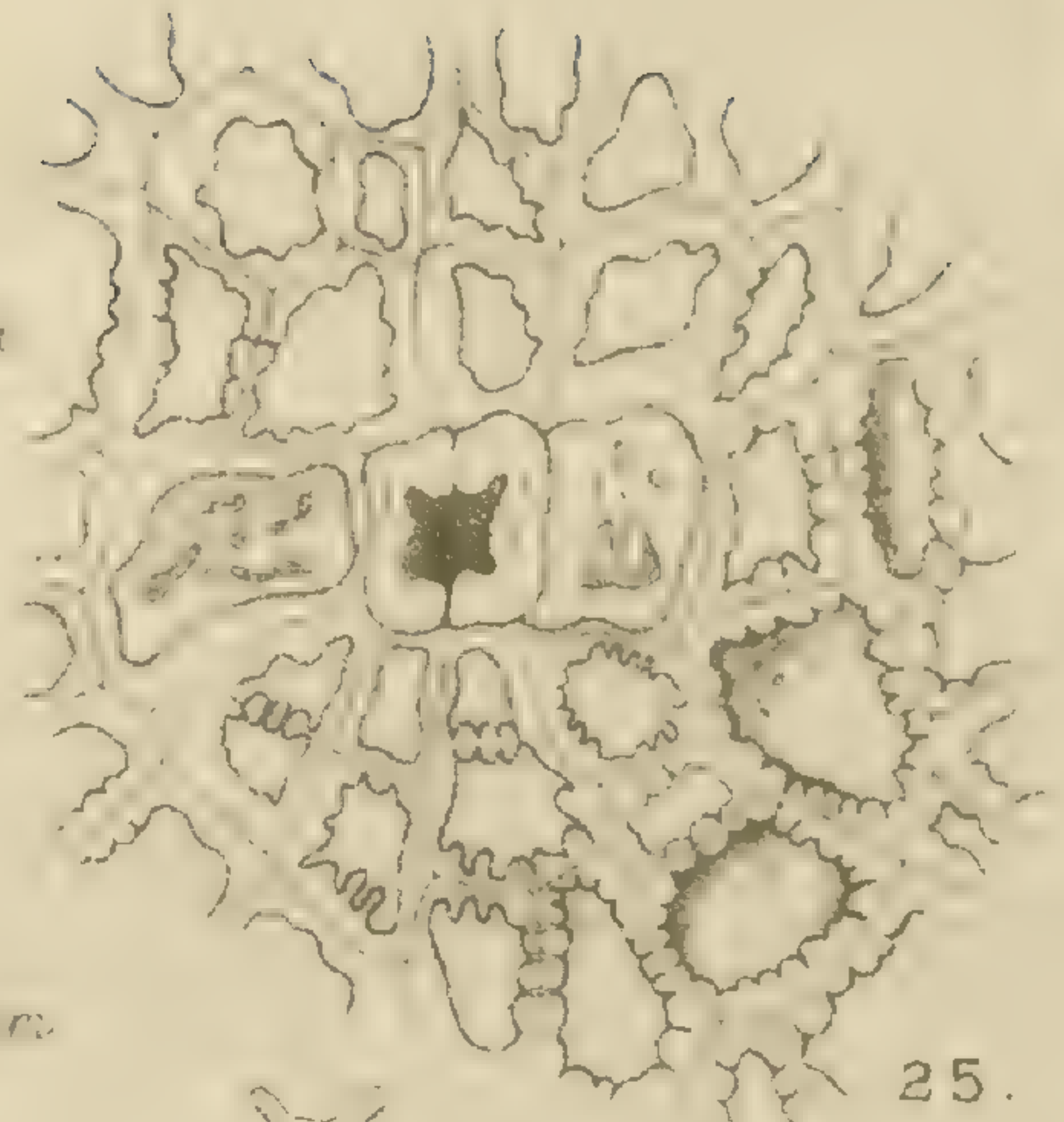

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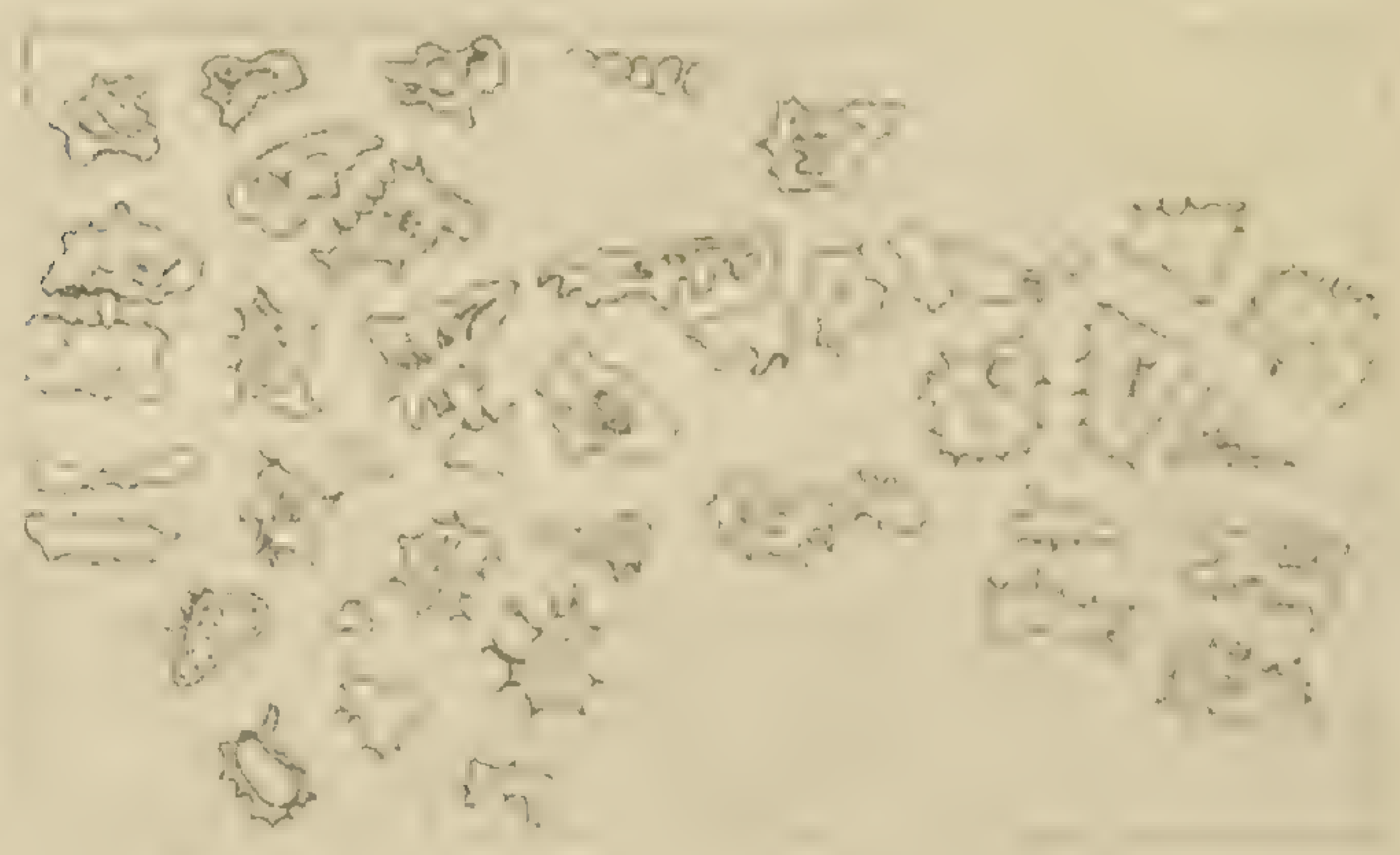

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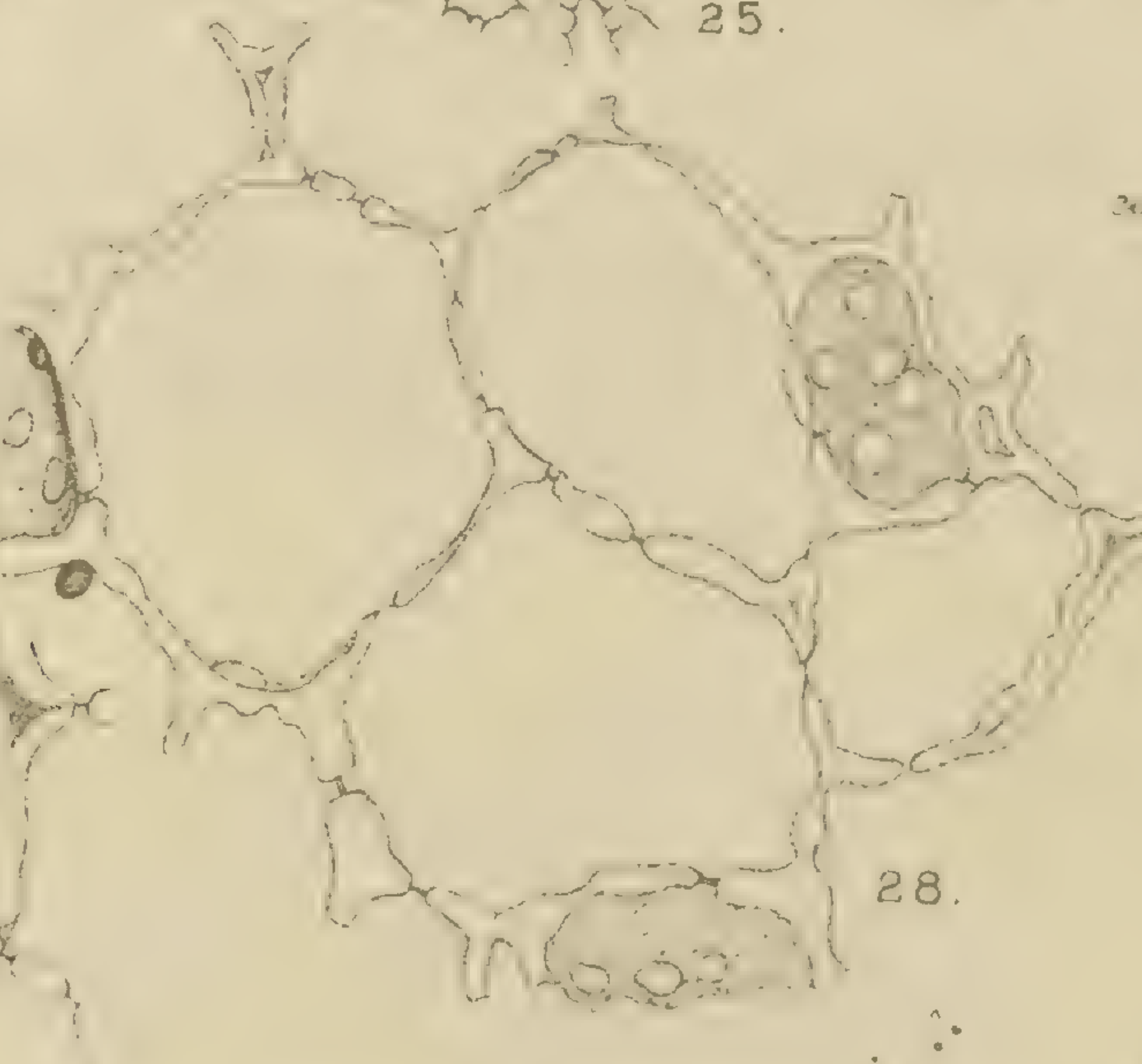

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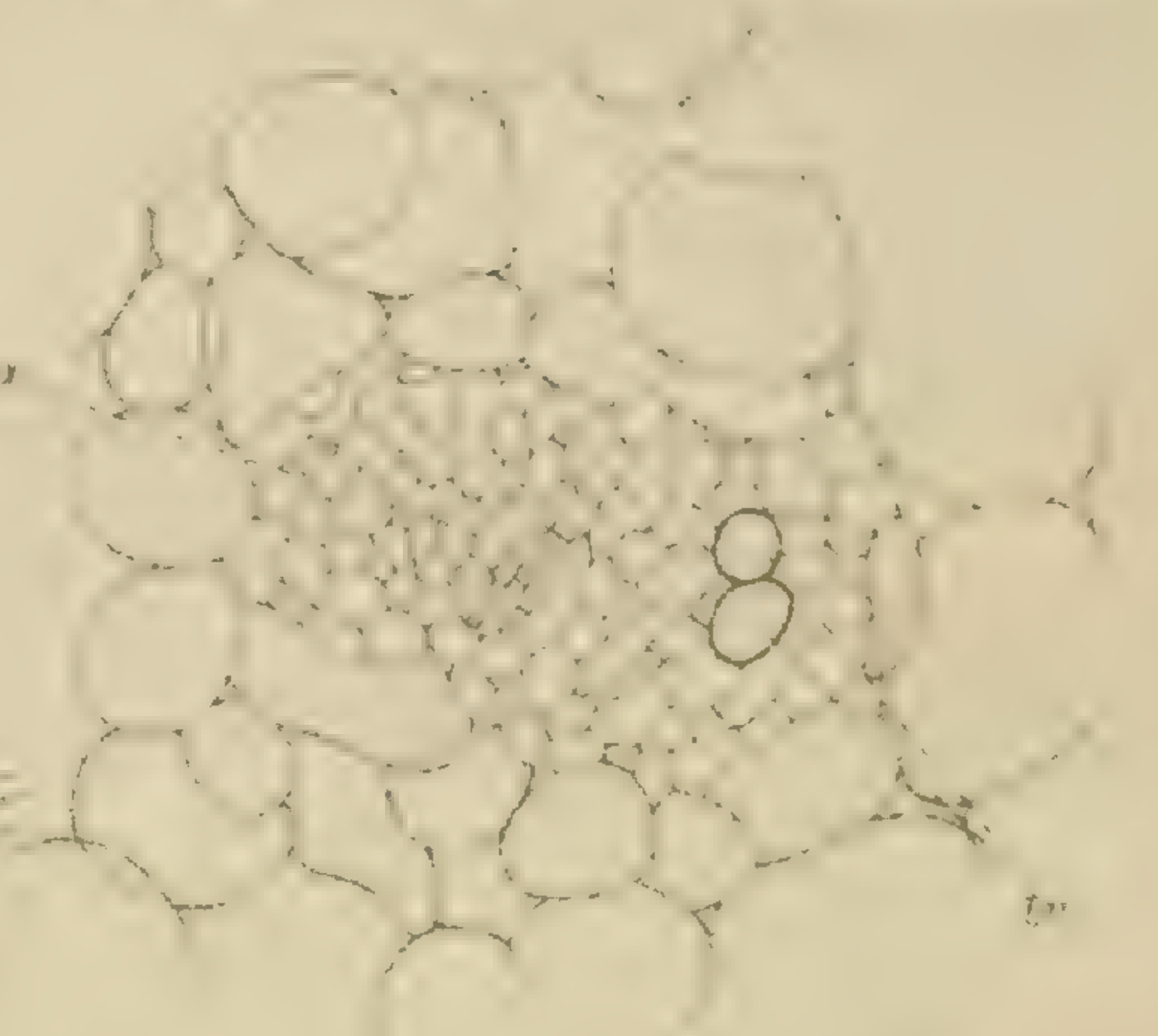

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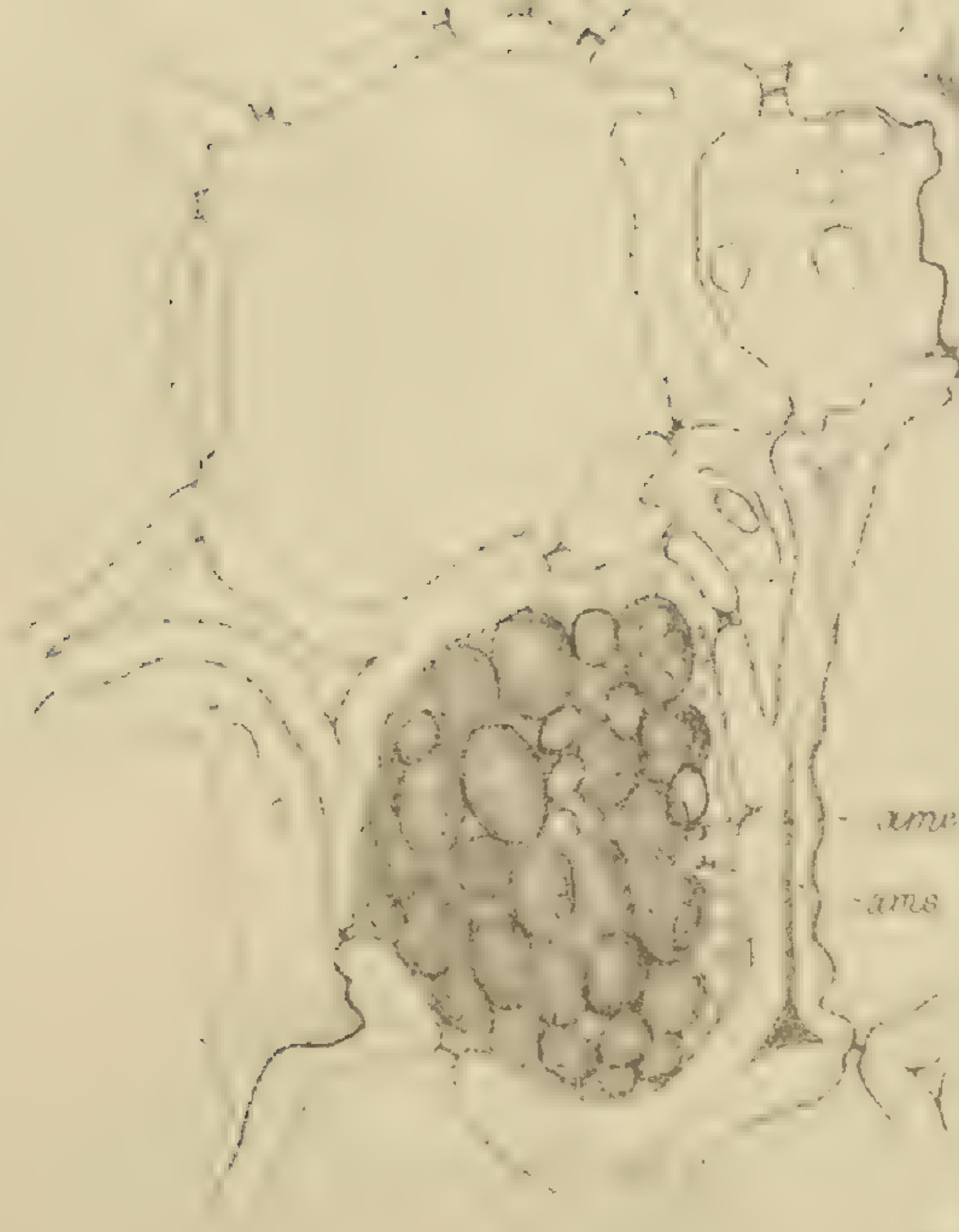

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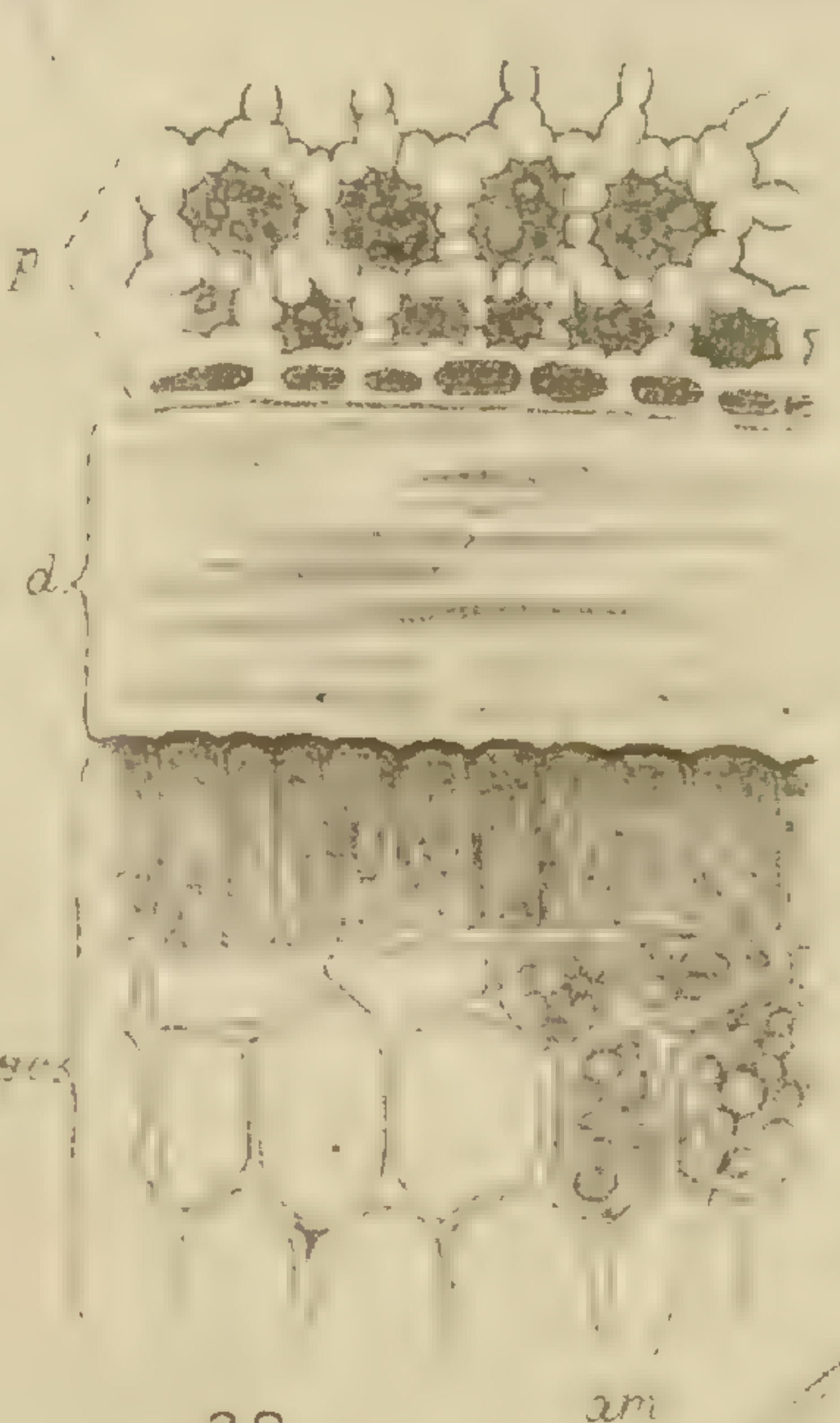
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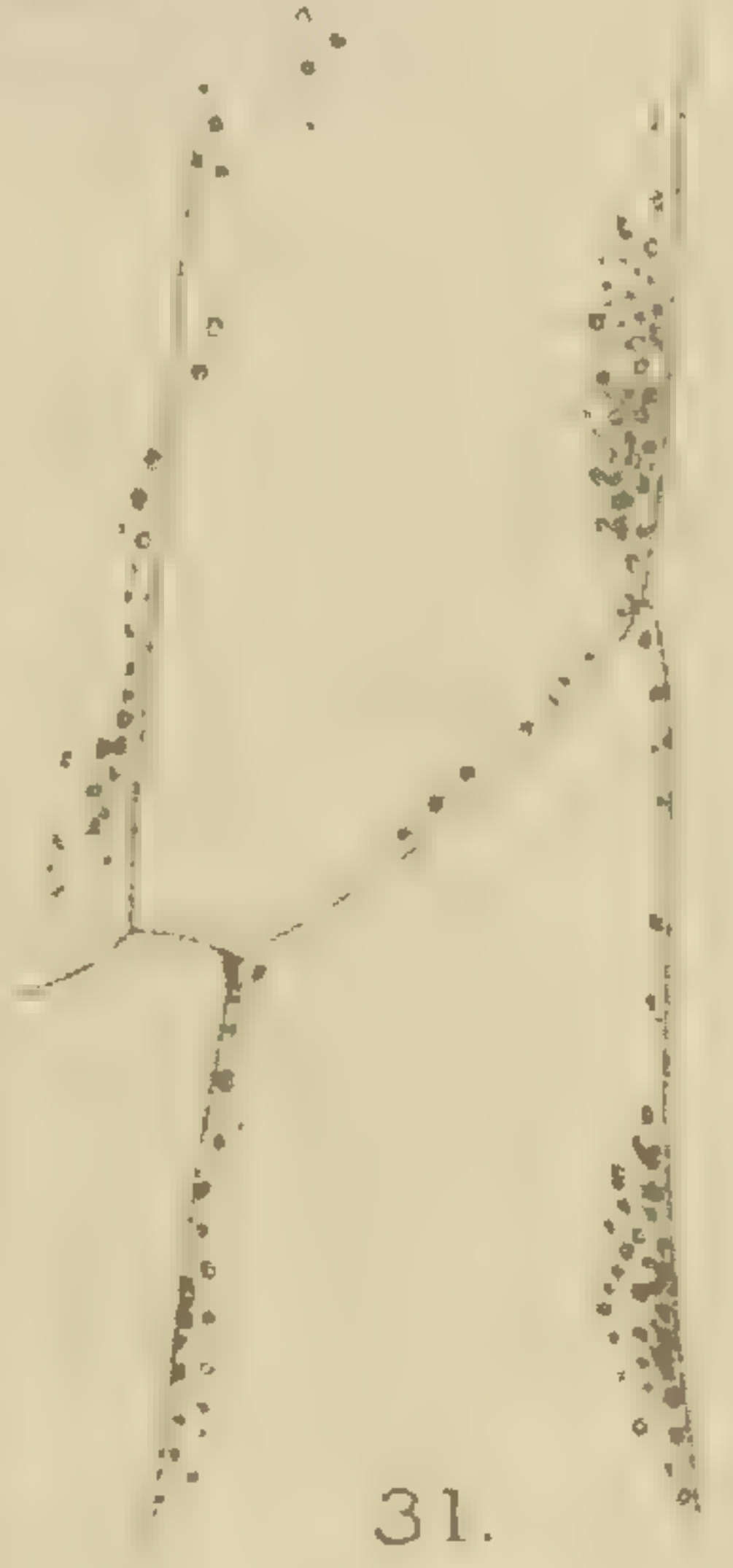

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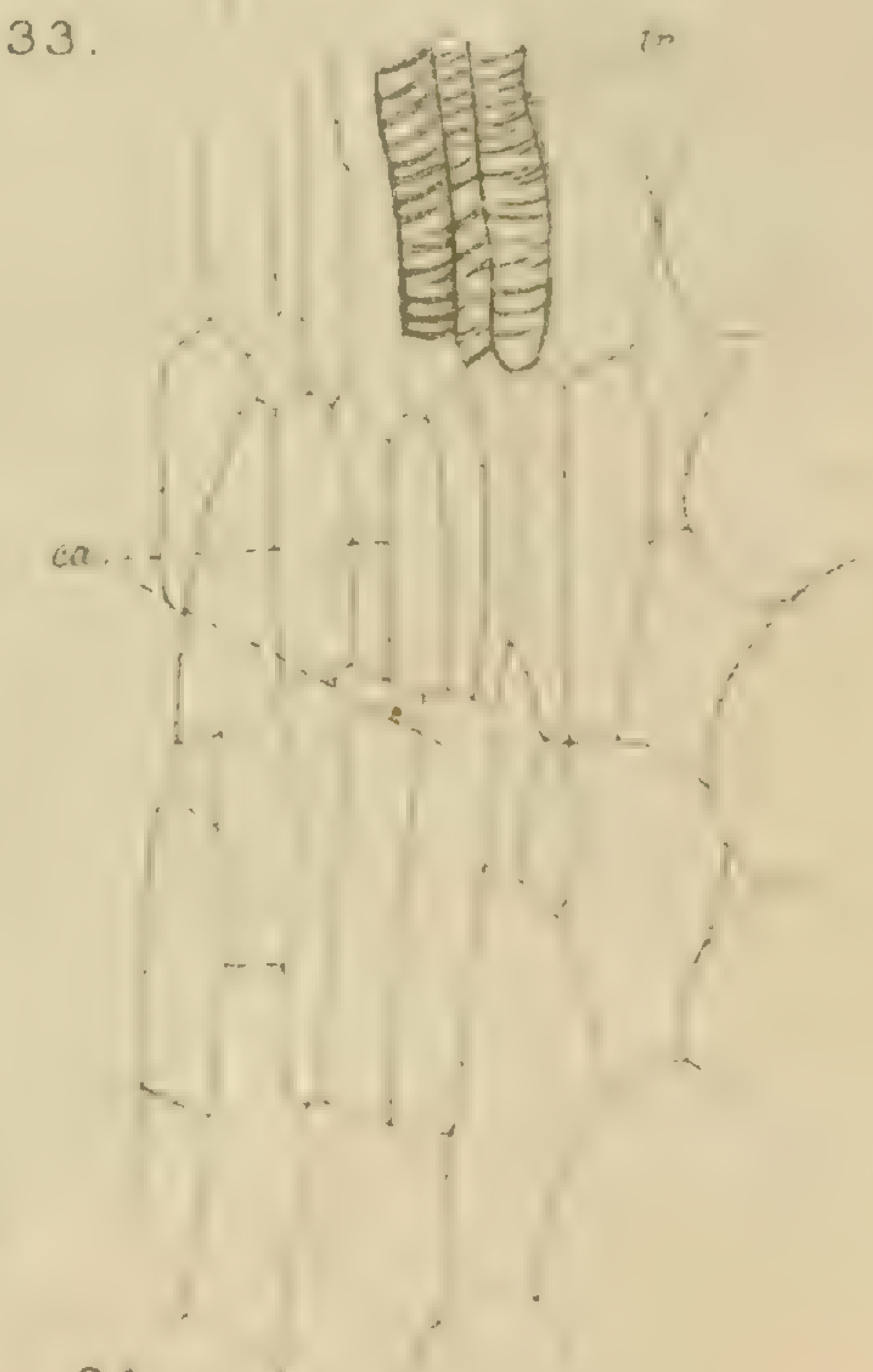

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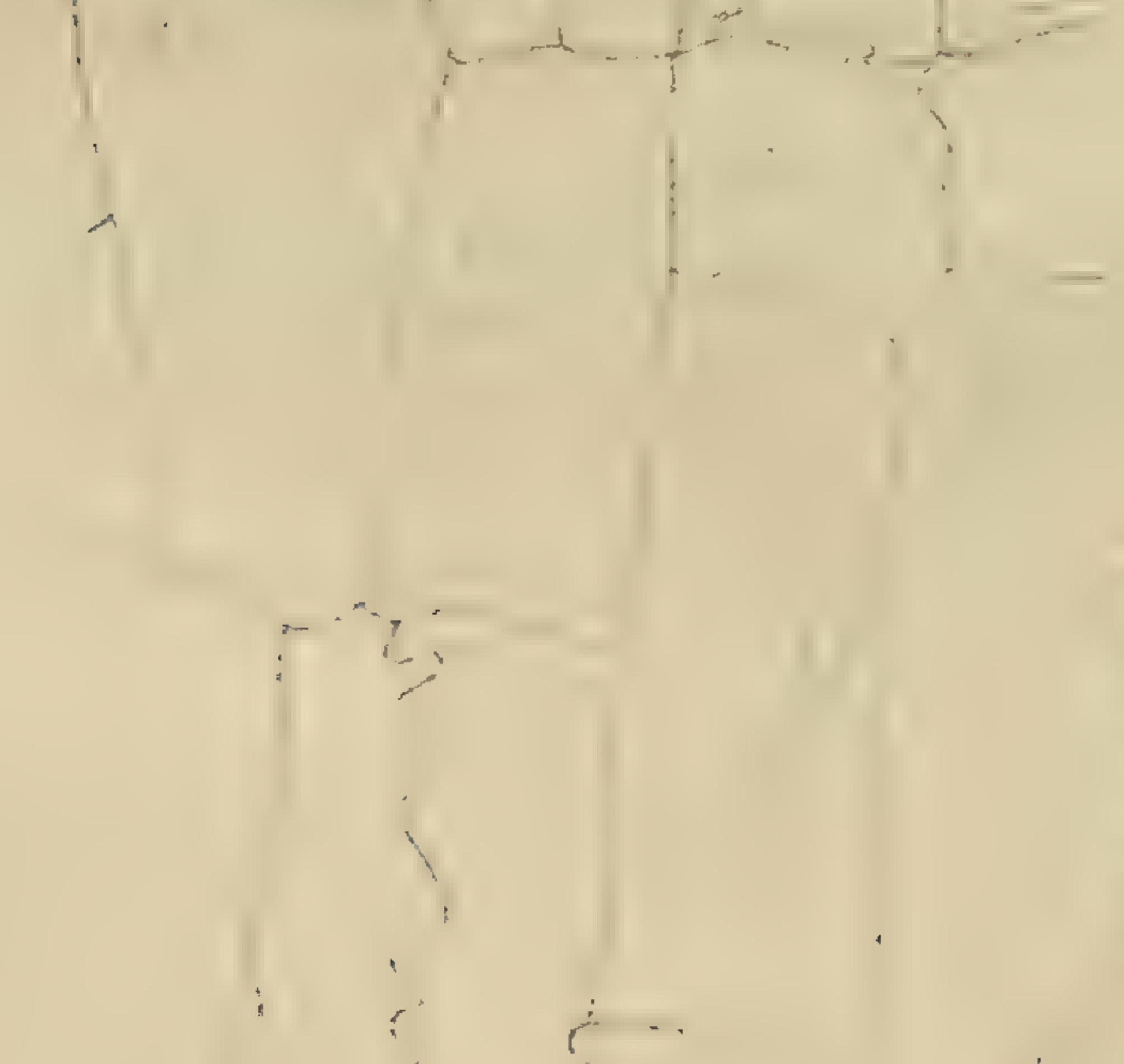

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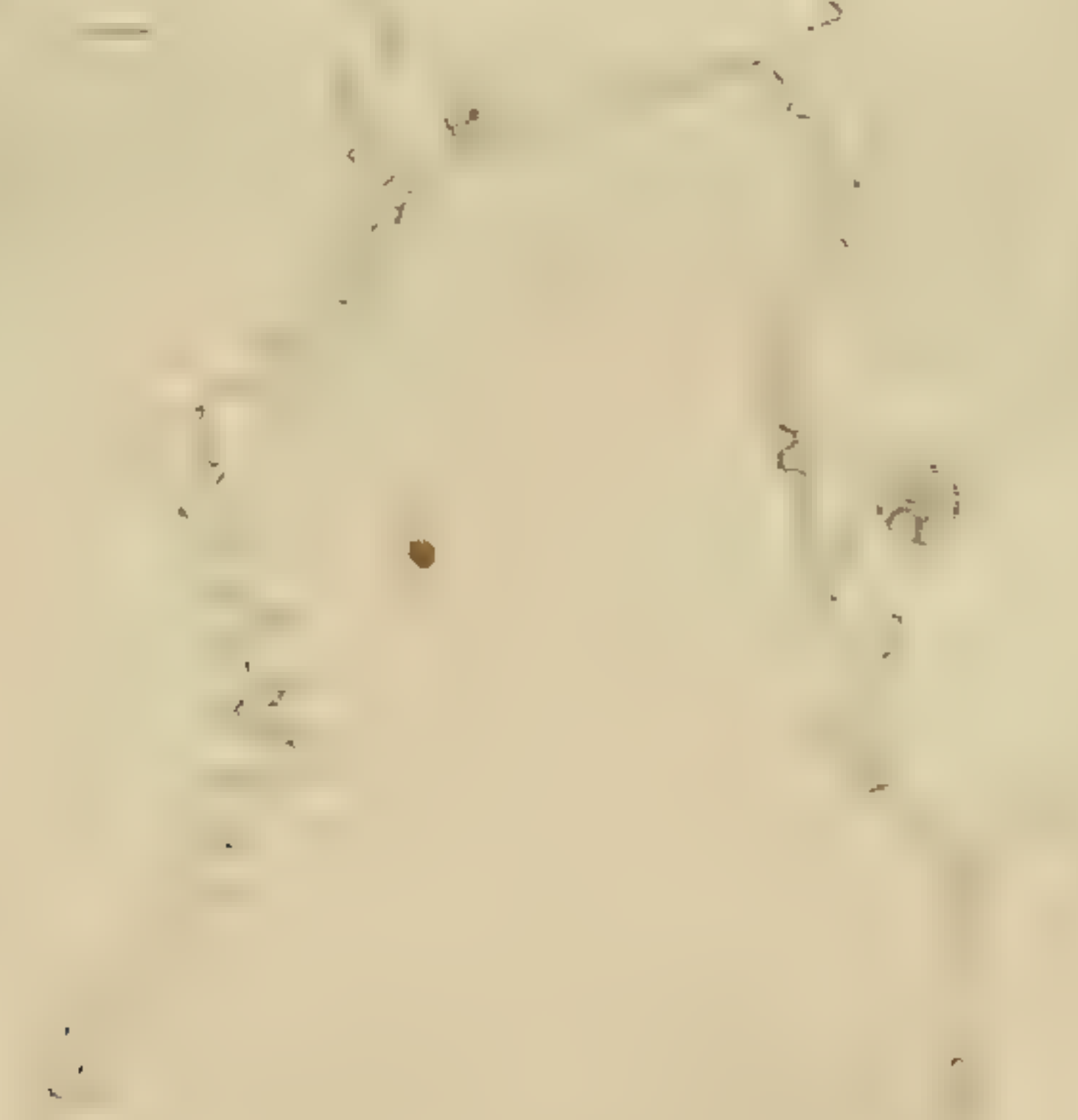

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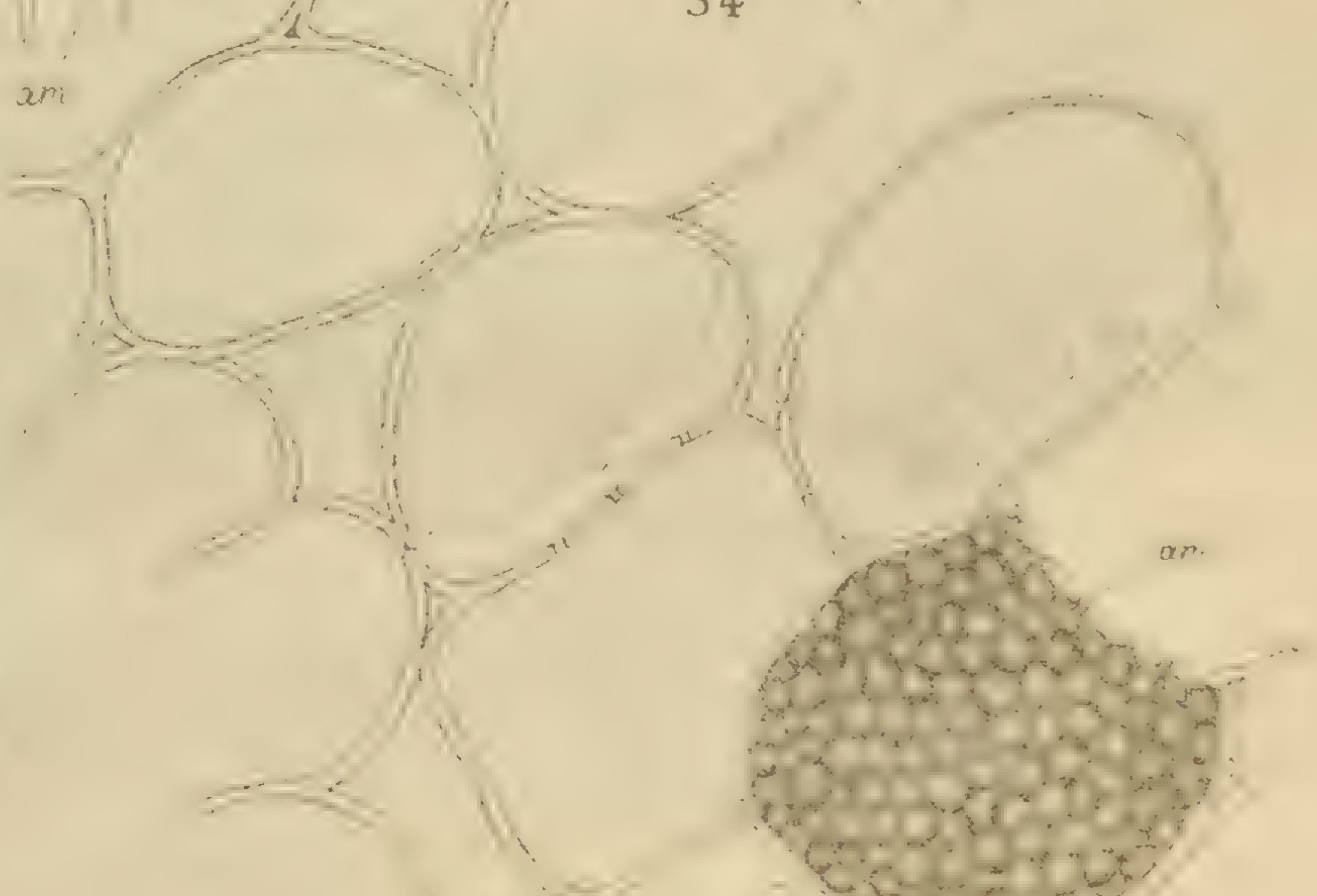

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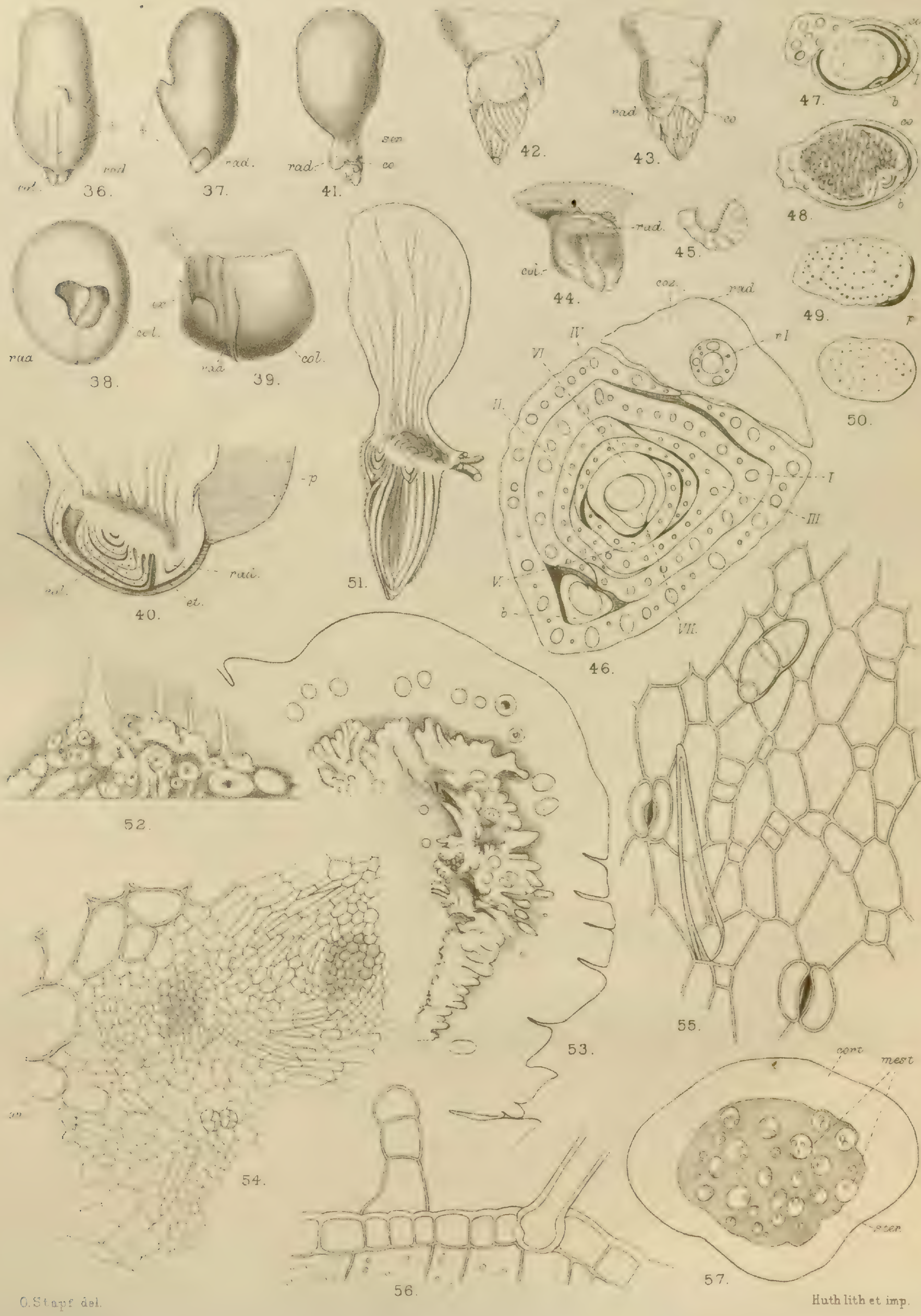
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	Part IV. 1895.	0	3	4	0	2	6
V.	Part I. 1895.	0	9	0	0	6	9
	Part II. 1895.	0	12	0	0	9	0
	Part III. 1896.	0	6	0	0	4	6
	Part IV. 1896.	1	0	0	0	15	0
	Part V. 1896.	0	14	0	0	10	6
	Part VI. 1896.	0	4	0	0	3	0
	Part VII. 1897.	0	4	0	0	3	0
	Part VIII. 1897.	0	6	0	0	4	6
	Part IX. 1899.	0	12	0	0	9	0
	Part X. 1899.	0	6	0	0	4	6
	Part XI. 1899.	0	7	0	0	5	0
	Part XII. 1899.	0	12	0	0	9	0
	Part XIII. 1900.	0	1	6	0	1	2
	Part XIV. 1900.	0	3	0	0	2	3
	Part XV. 1901.	0	6	0	0	4	6
VI.	Part I. 1901.	1	10	0	1	2	6
	Part II. 1901.	0	6	0	0	4	6
	Part III. 1902.	0	18	0	0	13	6
	Part IV. 1903.	0	8	0	0	6	0
	Part V. 1903.	0	8	0	0	6	0
	Part VI. 1903.	0	12	0	0	9	0
	Part VII. 1904.	0	12	0	0	9	0
	Part VIII. 1904.	0	12	0	0	9	0
	Part IX. 1904.	0	7	0	0	5	3

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ON THE ANATOMY OF THE ROOTS OF PALMS.

BY

DR. ERIC DRABBLE, F.L.S.

NATURÆ DISCERE MORES

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X. *On the Anatomy of the Roots of Palms.*

By ERIC DRABBLE, *D.Sc., F.L.S., Lecturer on Botany, St. Thomas's Hospital, London.*

(Plates 48–51 and 22 text-figures.)

Read 3rd December, 1903.

INTRODUCTION.

H. VON MOHL, in 1845, published an admirable account of the roots of Palms in his work 'De Structura Palmarum' (1). He described the typical arrangement of the tissues and observed that the central cylinder of the adventitious roots can be traced internally as a series of strands of xylem and phloem which penetrate deeply into the central cylinder of the stem. He also described and figured the cylinder of a large root of *Iriartia*, of which the outline is not circular, but deeply lobed in a stellate manner, the ends of the rays being usually bilobed. At the same time he gave an account of the medullary strands of fibrous or sclerenchymatous tissue, containing vessels and in some cases phloem also. He further noted that the fibrous ring in which are embedded the xylem- and phloem-bundles is often divided up into wedge-shaped masses by radial extensions of the medullary parenchyma.

The convergence internally of the xylem-bundles in pairs forming **V**'s, between the arms of which lie phloem-groups, was described in *Diplothemium maritimum* and *Chamædorea elegans*.

Karsten (2), in 1847, added to our knowledge of the anatomy of palms in a magnificently illustrated paper, in which a figure of the origin of adventitious roots is given showing some indication of the internally penetrating vascular strands in *Iriartia præmorsa*, Kl., and a figure of the lobed cylinder in the same species. A longitudinal figure of the apex seems to show that he found a single undifferentiated apical meristem.

Naegeli, 1858 (3), Russow, 1875 (4), and Falkenberg, 1876 (5), contributed incidentally to our knowledge of the histological structure of palm-roots, and De Bary, 1877 (6), summarized the work of all preceding investigators.

Van Tieghem, 1870 (7), in his first monograph on 'La symétrie de structure dans les Plantes vasculaires, (i.) La Racine,' describes the roots of *Phœnix dactylifera* and *Seaforthia elegans*.

Olivier, 1880 (8), cites Flahault's work on the primary root-apex in *Phœnix dactylifera*, describing it as possessing a well-defined plerome-initial group and a second group common to the other layers. Olivier also describes and figures a zone of sclerenchyma in the internal portion of the parenchymatous cortex, immediately external to the endodermis.

Mangin, 1882 (9), in a very important paper entitled "Origine et Insertion des Racines adventives . . . chez les Monocotyledones," gives an accurate account of the connection of the bundles of adventitious roots with those of the stem. He shows that the young root first appears as a papilla formed by local hypertrophy of the pericycle; in this young root the vascular elements arise and differentiate both internally, *i. e.*, in the ground-tissue of the central cylinder of the stem, acquiring connection with the scattered stem-bundles, often penetrating very deeply into the stem, and also externally into the developing root-apex, keeping pace with the growth in length of the young root, in which the bundles are arranged in a circle embedded in a fibrous or sclerenchymatous zone generally conforming to the typical root-structure of Monocotyledons.

Drude, 1887 (10), in his article on the Palmaceæ in Engler and Prantl's 'Natürlichen Pflanzenfamilien,' gives a short account of the buttress-roots and contractile roots of some palms.

Cormack, 1896 (11), made a great step in advance when he discovered what he termed a "polystelic" condition in the roots of *Areca*, and the common occurrence of a lobed and interrupted cylinder in many palm-roots. He grouped the arrangements met with under several headings, commencing with the normal type possessing a complete endodermis surrounding a central fibrous or sclerenchymatous ring in which lie the xylem and phloem elements. Passing through the condition in which the cylinder is still complete, but longitudinally lobed, the endodermis dipping into the depressions but being quite continuous, he came to those roots in which the central cylinder is composed of a series of independently running strands of fibrous tissue presenting the form of arcs of circles in transverse section; between these the endodermis dips in and becomes discontinuous; and finally he described the case of *Areca*, where one or more of these independent strands presents a complete radially symmetrical cylinder or "stele," as he terms it, round which the endodermis is complete. Cormack further shows that some roots exhibit the more complicated of these conditions in the proximal regions and the simpler types in the distal, and discusses the question as to whether this is due to secondary changes in the proximal regions brought about by dilatation-parenchyma, or other agency, acting subsequently to the apical development, or whether it is due to progressive simplification of the apical mersitem. He inclines to the latter view, supporting his contention by an ingenious deduction from the number of protoxylem-groups. He finds that the number of these is less in the distal and apical regions than in the proximal, and points out that production of a greater number of protoxylem-groups by secondary changes is extremely improbable if not impossible, and hence concludes that we are here dealing with a gradual reduction and simplification as apical development proceeds.

Cormack attempts an explanation of the peculiarities of structure met with in palm-roots based on physiological considerations of mechanical support, but does not attempt a morphological explanation.

Gillain, 1900 (12), describes the structure of the roots in a large number of Palms, but, curiously enough, he finds none with lobed or divided cylinders. He notices that the lateral roots in certain cases run through the cortex of the parent root for some distance before emerging. He finds three meristematic layers in the root-apex of *Kentia Forsteriana*, viz.: one for the plerome, one common to periblem and "dermatogen," and one for the root-cap.

Outline of Results of the present Investigation.

Mangin's account of the presence of many deeply penetrating strands of xylem and phloem establishing connection with the bundles of the stem is confirmed. These are traced into the apex of the young root *as separate strands* with such protoxylem as they possess arranged in an exarch manner, roughly alternating with phloem-groups. It is shown that these procambial strands, consisting of fibrous tissue enclosing xylem and phloem elements, are developed in a common ground-tissue at the non-stratified apex of the root, and that as development proceeds the more peripheral of these strands become arranged in what is at first an incomplete ring, passing distally into first a lobed cylinder, and finally into the normal cylinder of the root. All these stages are due to progressive changes in the procambial tissue of the meristematic apex.

Some of the more internal procambial strands do not enter into the fibrous ring, but persist as the well-known medullary strands, each presenting proximally a radial structure, with xylem and phloem well developed, but reduced distally, so that we find (i.) strands containing a few vessels only, accompanied by one or more phloem-groups; (ii.) one or two large vessels and a few smaller ones, unaccompanied by phloem; and (iii.) a single large vessel without accompanying smaller vessels or phloem.

All cases examined show the presence of a central cylinder composed of separate strands, passing into the lobed cylinder (*i. e.*, Cormack's *Areca*-type) in that portion of the root which runs through the cortex of the stem.

Usually the apex undergoes complete simplification while passing through the cortex of the stem, resulting in the production of a normal root cylinder, and hence the external root is normal; but in certain cases (e. g., *Areca*, *Kentia*, &c.) the simplification is much more gradual, the external root exhibiting the completely separate strands, as in *Areca* sp., or the lobed cylinder, as in *Kentia* sp.

In consideration of the method of development, it is claimed that the idea of a pith as a separate morphological entity is entirely precluded, the central parenchyma being merely that portion of the common ground-tissue which becomes enclosed by the gradually approximating and finally uniting procambial strands of the apex; it is always in complete continuity with "cortical" parenchyma proximally.

Buscalioni's account of the centrifugal appearance of the xylem elements of the bundle in roots of Monocotyledons, followed by the centripetal lignification, is confirmed for the palms; and the large scattered internal vessels of the fibrous cylinder are shown to be the persisting metaxylem elements of strands whose protoxylem has aborted.

ANATOMY AND HISTOLOGY OF THE ROOTS OF PALMS.

Origin of Adventitious Roots in the Stem.

The adventitious roots of the Palms have their origin in the pericyclic tissue of the base of the stem, in accordance with the method described by Van Tieghem and Douliot (13) for flowering-plants in general. The base of the stem is clothed with a dense cortex, usually very fibrous in nature and of considerable thickness, varying in different plants, but frequently several inches thick. Hence the pericyclic root arises deeply in the tissues of the parent stem. The root originates as a small papilla produced by division of the pericyclic cells. This papilla is provided externally with an extra-calyptral mantle or *poche* of small parenchymatous thin-walled cells, which presents its maximum thickness immediately over the apex of the papilla, thinning out laterally and exposing the underlying cells of the root-papilla.

Below the *poche* the apex is occupied by a group of meristematic cells, which, followed laterally, is seen to be separated into a thin external layer and a central group in which arises the procambial tissue, a zone of dark-coloured cells which eventually gives rise to the tegumentary system intervening between the two (Pl. 48. fig. 1, *a*, and fig. 3, *a*), exactly as figured by Karsten (2). The procambial tissue is here found in the form of a series of separate strands, which can be followed inwards into the stem for a considerable distance, running roughly at right angles to the stem-bundles (fig. 1, *proc.st.*). Thus only the distal extremities of the procambial strands are laid down in the shallow root-papilla, the internal portions arising by secondary divisions in the ground-tissue of the stem, as described by Mangin (9). The elements in this region are well differentiated, while the root itself is a mere pericyclic papilla (Pl. 48. fig. 1).

A slightly older root (fig. 3) presents essentially the same features. The papilla is now, however, considerably elongated and flexed downwards. Over the apex is the *poche*, which is continued for only a short distance up the root, the tegumentary tissue being exposed above it. The procambial tissue is here also in the form of separate strands (fig. 3, *proc.st.*).

In the cortex occur cells containing raphides. A transverse section through the apex of a pericyclic root-papilla shows a series of procambial groups of varying tangential extent scattered throughout the ground-parenchyma (fig. 7). In many cases the scattered procambial groups are much smaller and more numerous than in the root of *Kentia* figured. The more peripherally placed strands are delineated very definitely from the ground-parenchyma externally, but internally are much less distinctly bounded.

Passage of the Root through the Cortex of the Stem.

The root from its very inception projects into a well-formed cavity lying between it and the surrounding cortical tissues (Pl. 48. figs. 1, 2, and 3, *c*). This cavity is bounded by ragged cells, which show very clear signs of solution and disintegration. The external cells of the *poche* also show a similar appearance, and in some cases immediately outside the *poche* quite a mass of disorganized tissue occurs. The fibres of the cortex resist the solvent action longer than does the parenchyma, but eventually they, too, are destroyed, and the mineral matter, so often associated with the fibres, remains in the disorganized tissue in the form of scattered crystalline bodies.

Some of the parenchymatous cells of the cortical tissue in front of the advancing root-apex possess very dense granular protoplasm and large nuclei, thus presenting the normal appearance of secretory cells (Pl. 48. fig. 4). The elements which intervene between these and the cavity surrounding the young root are very clear and refractive, showing signs of approaching solution. It seems highly probable that a process of partial auto-digestion of the cortex, no doubt in response to a stimulus received from the young rootlet, precedes the final solution and absorption by the *poche*. Should this prove to be the case, it will afford an interesting parallel to Prof. Reynolds Green's observations on the digestion of the endosperm in certain seeds. He shows that solution is not entirely dependent on the direct action of the embryo, but sets in as the result of metabolic activity induced by the endosperm-cells themselves.

Root-apex.

Janczewski (14) described the root-apex of Monocotyledons as presenting a well-defined plerome-initial layer, a calyptrogen-layer, and an intermediate layer only one cell in thickness which splits behind the apex into dermatogen and periblem.

Treub (15) finds in palm-roots a well-defined pleromic group, covered by an initial layer common to calyptrogen, dermatogen, and periblem.

Cormack (11) describes the larger roots as possessing an "enchevêtrement des trois initiales."

Gillain (12) investigated the apex of *Kentia Forsteriana*, and says: "dass derselbe dem gewöhnlichen Typus der *Monocotyledonen* entspricht, also drei Schichten zeigt: eine für Plerom, eine gemeinsame für Periblem und Dermatogen und eine für die Würzelhaube," being thus in agreement with Janczewski.

In the present investigation the apices of large roots of *Areca* sp. and *Kentia* sp. were examined in serial microtome-sections, taken both longitudinally and transversely. The meristem was found to consist of a common initial group similar to that described by De Bary for *Vanda* (6) and by Janczewski (14) for the Cucurbitaceæ and Papilionaceæ (Pl. 48. figs. 5 & 6). The apical meristem is very bulky, and this renders it somewhat difficult to determine the median section. There is no doubt, however, that from this common apical group radiate lines of cells in all directions, the outer cells giving rise to the root-cap, the lateral ones to the "cortical" portion of the ground-parenchyma, and the axial cells to the "medulla."

In the ground-parenchyma certain strands of cells become slightly elongated and produce the procambial strands, which are thus merely local differentiations in the common ground-tissue (Pl. 48. fig. 5, *proc.tiss.*).

If the root be a short one (*i. e.*, if it has not progressed far beyond the pericyclic-papilla stage), the procambial tissue will be found to have the form of a series of independent strands (Pl. 48. figs. 7 & 8). More distally in a longer root it will present the form of a lobed cylinder (Pl. 48. fig. 9), and in a still longer root that of a complete circle (Pl. 48. fig. 10) as in the normal roots of Monocotyledons.

A transverse section through the apex in the region of the meristem-group shows radiating lines of cells extending from the centre to the periphery, the various layers of the root arising by subsequent differentiation in these cells.

Root-cap.

A longitudinal section of the apex shows the root-cap to be merely a local specialization of parenchyma formed from the extremities of the rows of cells radiating from the common meristematic group. As these cells approach the surface they become elongated (Pl. 48. fig. 13) and gradually exfoliate. The cells are dark-coloured; the middle lamella is destroyed by strong sulphuric acid, and the individual elements can be thus isolated. The internal walls are highly cuticularized and very resistant to the action of the acid.

In the outer cells the lumina may be entirely occluded by a dark-coloured substance giving cork-reactions.

Partial occlusion resulting in considerable reduction of the lumen may occur in more internal cells of the root-cap (Pl. 48. fig. 14).

The macroscopic appearance presented by the root-cap in *Kentia* and most other forms is that of a much-indurated dark-coloured smooth coating to the apex, extending for about an inch up the root (Pl. 48. fig. 11).

In *Areca* sp. (Pl. 48. fig. 12) and *Iriartia* sp. a different form of root-cap is shown. Instead of presenting a smooth surface, the outer layers of the cap are partially exfoliated and appear as an irregular covering of overlapping scales, closely resembling the same structure in *Philodendron* figured by Olivier (8) and in *Pandanus* figured by Van Tieghem (16).

The Limiting or Piliferous Layer.

An inch or so from the apex the root-cap is entirely exfoliated, or only represented by a few isolated broken-down elements adhering to the surface of the root. More proximally the surface is occupied by the so-called "limiting layer" ("epidermis" of authors). The term "piliferous layer" is not generally applicable in a strict sense in Palms, as in no case was any development of root-hairs observed. Gillain (12), however, appears to have found them in one instance, as he says: "nur bei *Trachycarpus excelsus,* finden wir Haargebilde." The cells of this layer frequently project as papilliform structures, as described and figured by Karsten (2) for *Iriartia.*

The walls of this layer are generally cuticularized and comparatively thin. This layer is shown for *Kentia* in Pl. 48. fig. 14; for *Caryota ochlandra* in Pl. 48. fig. 15; for *Phœnix sylvestris* in Pl. 48. fig. 16; and for *Dypsis madagascarensis* in Pl. 48. fig. 17.

The limiting layer does not represent any definite morphological stratum, but cuts through a series of lines of cells radiating from the meristem. It can be traced in an apical direction for a considerable distance underneath the root-cap, the cells becoming gradually smaller the nearer they approach to the apex. At the apex it is quite impossible to say which cells will form the limiting layer.

The cells of this layer do not necessarily form a perfectly regular sheath, irregularities such as that figured in fig. 14 being not uncommon.

Tegumentary System.

Beneath the limiting layer usually lie several layers of elongated, lignified, and more or less pitted cells, followed internally by lignified fibrous elements. These together form the outermost cortical zone and will be referred to as the Tegumentary System. In such a case lignification commences in the external layers of the outer zone of square-ended cells and proceeds centripetally. Whilst this is going on, lignification sets in in the more internal fibrous zone and proceeds centrifugally. In many of the roots examined a layer of cellulose-walled elements intervenes between the two zones of the tegumentary system, which has not yet been reached either by the centripetally or the centrifugally proceeding lignification. This is well shown in *Phœnix sylvestris* (Pl. 48. fig. 16). In other cases lignification may be extensive in the outer zone but absent in the internal fibrous zone, and here lignification proceeds centripetally only, as in *Caryota ochlandra* (Pl. 48. fig. 15) and *Livistona chinensis*. In *Dypsis madagascarensis* (Pl. 48. fig. 17) the two outer layers only are lignified; these are followed by six or seven layers of square cells with dark contents, which resist the action of strong sulphuric acid and give all the reactions of cork.

In *Cocos nucifera* the tegumentary layers are much indurated.

In *Corypha australis* the outer elements are lignified, thick-walled, and pitted; the inner ones are square-ended and pass gradually into the internal parenchymatous cortex.

In *Sabal Palmetto* the outer elements alone are lignified and *all* are parenchymatous. In *Plectrocomia elongata* the inner elements are densely lignified and their lumina are almost occluded, while the outer layers are much less strongly lignified. The same holds good for many roots of *Kentia* sp. In *Ptychosperma perbrevis* the outer elements are fibrous and possess transverse walls, while the inner consist of extremely thick-walled deeply-pitted fibres. In *Phœnix dactylifera* the tegumentary layers are non-lignified, but cuticularized.

Many roots possess mucilage-cells in the tegumentary layers. These may be scattered through the outer zone, any cell being potentially a mucilage reservoir, as in *Dictyosperma album* and *Kentia Forsteriana*, or through the inner zone, as in *Cyrtostachys Renda*; or very definite mucilage-elements may be present, as in *Caryota* sp. (Pl. 49. fig. 42), where they take the form of elongated very thick-walled cells arranged in longitudinal series and containing raphides.

Both outer and inner zones originate as small-celled parenchymatous tissue in the apex (Pl. 48. figs. 13 & 14). The outer elements usually elongate and become pitted, but retain their square ends, while the inner elements generally become prosenchymatous.

The Inner Cortex.

The inner cortex, or cortex proper, viz., that region intervening between the tegumentary layers and the endodermis, is always composed of parenchymatous tissue, and is usually provided with lignified elements and large air-spaces.

The inner cortex may be divided into three zones: an external, which is usually without air-spaces; a broad middle zone, with large air-spaces; and an internal zone, in which the cells are more regularly arranged, conforming to the description given by Olivier (8) for the internal cortical zones in Monocotyledons.

Air-spaces.

The development of the cortical air-spaces was followed in *Kentia* sp. and in *Areca* sp. The process was found to be exactly similar in each.

A short distance behind the apex certain cells, usually in small groups of two or three as seen in transverse section, lose their contents and present a very refractive appearance in their walls (Pl. 48. fig. 18). These walls sooner or later disintegrate, and in this way a lysigenous space is formed (Pl. 48. fig. 19). These spaces enlarge by the disintegration of more cells, and their boundaries nearly always present the remains of the partially dissolved cells (Pl. 48. fig. 20).

Various Forms of Air-spaces.

In *Phytelephas macrocarpa* (Pl. 48. fig. 21) the air-spaces are always small, even in the mature root, being formed merely by the disintegration of 3–10 cells as seen in transverse section. These spaces are irregularly scattered throughout the cortex.

In *Kentia* sp. (Pl. 48. fig. 20) the air-spaces are more extensive and are radially elongated; they are very numerous and irregularly scattered.

In *Metroxylon Sagu* (Pl. 48. fig. 22) they are more confined to the internal zone of the cortex, and in *Iriartia* sp. (Pl. 48. fig. 23) only a single ring of rounded cavities is present in the innermost cortical zone, immediately surrounding the endodermis.

In *Phœnix sylvestris* (Pl. 49. fig. 30) they are very numerous and occupy nearly the whole of the cortical region. They are more or less rounded, having individually very little radial extension, and are separated from one another only by a single or double layer of cells.

In *Caryota australis* (Pl. 49. fig. 29) the disposition is similar, but here the remains of the disintegrated cells may be clearly seen as diaphragms in the lumina of the air-spaces. The same is true to a less extent in *Phœnix sylvestris* (Pl. 49. fig. 30). In *Licuala spinosa* (Pl. 49. fig. 28) the spaces are radially greatly extended and occur in two rings, the spaces of the inner ring being much larger than those of the outer. In *Licuala gracilis* (Pl. 48. fig. 24) there is only a single ring of radially very extensive spaces, which extend almost from the endodermis to the tegumentary layers.

The air-spaces present no resistance to the growth of the surrounding parenchyma, and in some cases (e. g., *Areca Catechu*) advantage is taken of this; some of the surrounding cells project into the cavity and there swell and undergo division (Pl. 48. figs. 25 & 26), and in this way the air-spaces may become completely filled with a secondary tissue. This tissue becomes lignified and pitted and the peculiar condition figured in fig. 27 results.

Lignified Elements of the Cortex.

Nearly all palm-roots possess some lignified elements in the parenchymatous cortex. Only in *Phytelephas macrocarpa* (Pl. 48. fig. 21), *Thrinax parviflora*, and the contractile roots of *Corypha umbraculifera* was lignification found to be entirely wanting.

The simplest form in which lignification appears is that of lignified parenchyma. This occurs in *Latania borbonica*, *Cocos nucifera*, and *Acanthoriza australis*. The cell-walls are thin, and only differ from normal parenchyma in their reactions. In *Sabal Adansonii* the elements are distributed throughout the cortex, and in all specimens of *Licuala* (Pl. 48. fig. 24 & Pl. 49. fig. 28) and *Livistona* examined they occur in longitudinal strands. In these genera the walls are thicker and are pitted.

In *Cocos botryophora*, *Diplothemium maritimum*, *Bactris minor*, and *Sabal Palmetto* (Pl. 49. fig. 33) some of the elements become definite stone-cells in the innermost zone of the cortex; and in *Cocos plumosa* and *Caryota urens*, a definite zone of stone-cells surrounds the endodermis. These elements are first mentioned as occurring in palm-roots by Gillain (12). He, however, only gives a short description and does not figure them. They are usually thick-walled, deeply pitted, square elements, but they may be quite spherical or may be elongated. In *Caryota urens* the thickening of the walls is so extensive that the lumina are almost entirely occluded.

Quite a different type of element is represented in the fibres so plentifully developed in most palm-roots. These are of two distinct types:—

(*a*) The *Kentia*-type. These are long-pointed elements, with comparatively thin and more or less pitted walls and large lumina. In some cases transverse walls are present, as in *Euterpe* sp.

These fibres may occur singly, as in *Hyophorbe amaricaulis* (Pl. 49. fig. 35), *Latania Loddigesii*, and *Euterpe* sp., but are much more generally collected into bundles as in *Kentia* (Pl 48. fig. 20 & Pl. 49. fig. 36), *Areca Catechu* (Pl. 48. fig. 25), and *Cyrtostachys Renda*. In this last species the fibres conform generally to the *Kentia*-type, but are shorter than usual.

(*b*) The *Raphia*-type. These fibres are longer, narrower, thicker-walled, and more densely provided with simple pits than are those of the *Kentia*-type. They may occur singly, as in *Pinanga Kuhlii* and *Pinanga* sp.; but are nearly always collected into very definite bundles traversing the cortex, as in *Raphia Hookeri* (Pl. 49. fig. 37), all species of *Phœnix* examined (Pl. 49. fig. 30), *Metroxylon Sagu*, *Dictyospermum album*, and *Seaforthia elegans*, the last species being particularly richly supplied.

Bundles of fibres of the *Raphia*-type are generally provided externally with the so-called *stegmata*, under which name Mettenius (17) described certain small cells of the nature of "covering-plates" occuring in *Trichomanes*. Rosanoff (18) showed that these occur commonly in Monocotyledons also. De Bary (6) says "they always appear on the outer surface of sclerenchymatous or sclerotic bands of fibres (either such as pursue a separate course or accompanying vascular bundles) and are applied to these in longitudinal rows. The single elements are small and have the form of flat or (in Monocotyledons) plano-convex, usually rectangular plates with the flat side contiguous with the fibrous band. As regards their structure, they are characterized by unequal thickening on different sides, usually also by partial silicification of their walls. . . . . The fibrous bands in the stems, leaves, and roots of . . . . Palms (*Chamærops*, *Phœnix*, *Caryota*, &c.) . . . . have interrupted longitudinal rows of plano-convex stegmata on their surface. The convex outer wall of these is thin, the inner thickened to a half-spherical rough body, which almost fills the cavity and consists mostly of compounds of silicon."

In the Palms examined these stegmata have only been found in connection with the *Raphia*-type of fibre (Pl. 49. figs. 37 & 32, *steg.*). In general they agree very well with De Bary's description, but the body of the roughened inner wall, though showing some silification, also appears to be rich in calcium oxalate, as might be expected, when it is remembered how constant is the association of this substance with any rapidly growing tissue (apices) or elongating elements (fibres). Percival (19) has recently called attention to crystals of calcium oxalate in the cells bordering the developing fibres in *Trifolium*, and it appears certain that this substance is in some way intimately associated with carbohydrate metabolism, probably being formed by the precipitation of oxalic acid or acid potassium oxalate in an insoluble form, as believed by Schimper.

In the above account of the stereome-tissues of the cortex, no mention has been made of the association of different types of element, although it is very unusual to find one type alone represented.

Lignified parenchyma occurs alone in *Latania borbonica*. It is associated with stone-cells in *Cocos botryophora*, *Diplothemium maritimum*, *Bactris minor*, *Sabal Palmetto* (Pl. 49. fig. 33), *Caryota Rumphiana*, and *Caryota urens*, and with fibres of the *Raphia*-type in *Martenezia Lindeniana*, *M. caryotifolia*, *Hyphæne thebaica*, and *Plectocomia elongata*.

Stone-cells have in no case been found to occur alone. They are associated with lignified parenchyma in the roots mentioned above, and with fibres of the *Kentia*-type in *Oncosperma fasciculatum*.

Fibres of the *Kentia*-type occur alone, both individually and in bundles, in *Ptychosperma perbrevis*, and in *Actinorhytis Calapparia*, where they are of the *Kentia*-type in the external zones, but more definite within.

Fibres of the *Raphia*-type occur alone in *Dictyosperma album*, where they are very abundantly developed, and in *Metroxylon Sagu*.

In *Arenga Wightii* lignified parenchyma, stone-cells, and fibres of the *Raphia*-type occur.

In the young root of *Dictyosperma album* a bundle of fibres with two small tracheidal elements was found, and in *Iriartia* sp. each bundle of fibres contains centrally a thin-walled element, presenting the appearance of a young sieve-tube, but it was impossible to obtain material of roots in which the development was sufficiently advanced to settle this point. De Bary (6) observed the same thing, and says, "in the outer parenchyma . . . . of the cortex . . . . numerous small bundles of sclerenchymatous fibres lie, each enclosing in its centre 1–2 thin-walled elongated elements (perhaps sieve-tubes ?)."

Lignification in any bundle of fibres commences in the external elements and progresses towards the centre.

In some mature roots the external fibres of any bundle may be fully lignified, while the inner elements retain their cellulose walls.

These results may be summarized as follows :—

The simplest form of lignified element—namely, the thin-walled parenchymatous cells, whose walls give lignin-reactions—may undergo specialization in one of two directions:—(1) The walls may become thickened and pitted, the extreme form being a densely sclerosed stone-cell, or (2) elongation of the cell may take place, leading to the appearance of individual, comparatively thin-walled fibres scattered irregularly throughout the parenchymatous cortex. Fibres of this type are often collected into bundles—the *Kentia*-type of the foregoing description. In other cases the fibres are greatly extended and their walls considerably thickened with consequent reduction of the lumina. This latter type of fibre—the so-called *Raphia*-type—usually occurs in bundles, accompanied externally by small crystal-containing sacs, or stegmata.

Mucilage-sacs and Raphides-containing Elements.

The cells of the tegumentary layers frequently contain dark-coloured mucilage. Occasionally definite thick-walled mucilage-reservoirs containing raphides are also present in this zone, as in *Caryota* sp. (Pl. 49. fig. 42).

Individual mucilage-cells may also be scattered throughout the cortex and pith.

Specially developed elements containing bundles of raphides composed of calcium oxalate embedded in mucilage are regularly formed at the apex. These first appear as elongated cells in the cortical or medullary parenchyma, in which bundles of raphides develop, occupying nearly the whole lumen of the cell, the protoplasm and nucleus being relegated to one, usually the upper, end (Pl. 49. fig. 38).

These cells are arranged in rows, and keep pace in growth with the longitudinal extension of the stem, but do not undergo any division. Hence very considerably elongated elements result. The contents of these cells become very mucilaginous (Pl. 49. figs. 38, 39, & 40), and the nucleus appears to fragment (Pl. 49. fig. 40) and finally disappears. These elements are usually very abundant and well developed in the younger portion of the root, but become more or less obliterated in the older portions.

Hanstein (20) discussed the question as to whether the mucilage-spaces in Monocotyledons are formed by the fusion of more than one element by the disappearance of transverse walls, and from his study of *Commelina* concluded that such is the case—raphide-containing vessels resulting.

De Bary (6) was unable to substantiate this. He found, however, that the transverse walls might become perforated by the absorption of water and consequent swelling of the mucilage during the preparation of sections, and suggested that this might also occur in nature. De Bary's conclusion that absorption of transverse walls does not take place is entirely borne out by an examination of the roots of Palms. Here the crystal-sacs just behind the apex are nearly filled with raphides (Pl. 49. fig. 38). About half an inch behind the apex the cells have grown considerably in length, as have also the crystals themselves, but the transverse walls are still as definitely present as in the first case, no signs of any disappearing walls being seen (Pl. 49. fig. 39). In the older regions of the root the crystal-sacs have increased still further in length, and the bundles of raphides are very short in proportion to the length of the containing element (Pl. 49. fig. 40). If the long crystal-sac had been formed by cell-fusions several bundles of raphides should occur. Such is, however, not the case, and it is concluded that longitudinal fusion of cells does not take place. It is probable that the walls of the original sac become mucilaginous and disappear in the old root, and that the bundle of raphides, with its enclosing mucilage, does not occupy a cell at all, but rather an intercellular space which may become enlarged to any extent by growth of the surrounding elements.

Endodermis.

Round the normal cylinder the endodermis forms a complete circle. In the roots with a lobed cylinder the endodermis follows the contours of this, and in those cases in which the cylinder is made up of a series of separate strands the endodermis is well developed on the peripheral surfaces, but internally is lost, becoming merged into the general ground-parenchyma, except in a few cases, e. g., *Areca* sp., where a complete endodermal investment surrounds one or more of the strands.

The endodermis is composed of a single layer of cells, except in *Iriartia* and *Kentia* (Pl. **49.** fig. 48), where local doubling was observed. The constituent cells are generally 3–6 times longer than broad (Pl. **49.** fig. 46), but in contractile roots of *Corypha umbraculifera* they are short and square.

Occasionally, as in *Sabal Palmetto*, *Areca Catechu*, *Hyphæne thebaica*, and *Latania Loddigesii*, the cell-walls are composed of cellulose; in contractile roots of *Corypha umbraculifera* they are cuticularized, but much more commonly they are lignified.

In *Plectocomia elongata* the walls are very slightly lignified; in nearly all cases, however, all the walls except the external tangential are densely lignified and thickened in a manner recalling that of the cells composing the fibrous layer of an anther, as first pointed out by Von Mohl (1) (Pl. **49.** fig. 46). The internal wall is uniformly thickened and deeply pitted. From this extend bands of thickening on the radial walls, while the external walls are usually not thickened or only very slightly so (Pl. **49.** figs. 45 & 47). This condition obtains in *Phœnix sylvestris* (Pl. **49.** fig. 30), *Licuala gracilis* (Pl. **48.** fig. 24), *Licuala spinosa* (Pl. **49.** fig. 28), *Livistona olivæformis* (Pl. **49.** figs. 45 & 46), *Kentia* (Pl. **49.** fig. 47), and in the majority of palm-roots.

In *Raphia Ruffia* the thickening is almost equally deposited all round, the external tangential walls being thickened, and in *Metroxylon Sagu* the lumina are almost obliterated.

Non-lignified passage-cells are generally wanting, but occasionally occur. In *Phœnix sylvestris* they may occur at any point. In *Kentia* (Pl. **49.** fig. 47) two or three may occur together, generally opposite the protoxylem.

The process of lignification of the endodermis was followed in *Phœnix reclinata*. There is a tendency for it to commence opposite the phloem-groups, but this is by no means invariably the case. Usually several cells in contact, forming a tangential row, undergo lignification at the same time, their lateral neighbours being at this time quite unaltered, although they may later all undergo complete lignification, the mature root in this species showing no passage-cells.

A peculiar condition was observed in the endodermis of *Corypha australis* and the non-contractile roots of *Corypha umbraculifera*, some cells being cuticularized, while the rest were lignified.

Pericycle.

The pericycle is usually a very definite layer, but in the contractile root of *Corypha umbraculifera* it is ill-defined. Lignification generally obtains (Pl. **49.** figs. 45 & 46), but in *Plectocomia elongata* and *Phœnix sylvestris* the walls are thin and consist of cellulose. In *Sabal glaucescens* the elements are non-lignified, but scalariformly marked. In *Hyphæne thebaica* lignification is partial and in *Sabal filamentosa* general, but cellulose walls occur, particularly opposite the protoxylem.

The individual elements are almost invariably several times longer than broad, as in *Livistona olivæformis* (Pl. **49.** fig. 46).

In *Arenga Wightii*, however, they are short and square.

The pericycle may be one layer of cells in thickness throughout, as in *Livistona oliviformis* (Pl. **49.** figs. 45 & 46), *Caryota urens*, and *Caryota* sp.; or may be irregularly doubled opposite the phloem in *Sabal Adansonii*.

In other roots the pericycle is two-layered throughout. This occurs in *Areca Catechu*, *Caryota Rumphiana*, *Phœnix reclinata*, where the lignification is greatest opposite the phloem-groups; *Metroxylon Sagu*, in which the cells of the inner layer are much reduced in size opposite the protoxylem; and in *Geonoma pumila*, where the pericycle is compressed opposite the protoxylem and expanded opposite the phloem.

In *Cocos nucifera*, *Kentia* sp. (Pl. **49.** fig. 47), *Sabal filamentosa*, and *Hyphæne thebaica* the pericycle is typically two-layered, but is irregularly reduced to one layer at any point; while in *Cocos botryophora* and *Cocos plumosa* reduction to one layer occurs only opposite the protoxylem, and in *Latania Loddigesii* opposite both xylem and phloem.

In *Arenga Wightii* the two-layered pericycle becomes irregularly three-layered locally, and in *Sabal glaucescens* three layers occur opposite the phloem, the pericycle being elsewhere two-layered.

In *Sabal Palmetto* the pericycle is three-layered, and only reduced to two layers opposite the protoxylem.

In *Phœnix sylvestris* the pericycle is interrupted opposite the protoxylem and the external vessels abut directly on the endodermis, as De Bary (6) showed to be the case in grasses.

Fibrous Zone of Sclerenchyma.

Following the pericycle internally is a zone of fibrous tissue, generally of considerable radial thickness, in which lie the elements of the xylem and phloem. This normally presents the form of a regular circle in cross-section, e. g., *Sabal filamentosa* (Pl. **50.** fig. 75), but may be lobed internally, as in *Phœnix dactylifera* (Pl. **50.** fig. 68), externally (Pl. **50.** fig. 88), or may be incomplete on one side, as in *Dypsis madagascarensis* (Pl. **50.** fig. 63), or broken up into a number of separate strands, as in *Areca* sp. (Pl. **50.** fig. 56).

The elements of this zone are usually elongated lignified fibres, generally thick-walled and pitted. In some cases they are very densely lignified and indurated, as, for instance, in *Martinezia caryotifolia*.

Sometimes the elements are square-ended and shorter, being of a more definitely sclerenchymatous nature.

The fibres arise in the procambial strands, or procambial cylinder, as the case may be, at the apex of the root, and form the ground-tissue of these structures. The elements are at first small, somewhat elongated and square-ended, subsequent growth resulting in the fibrous nature of this tissue.

Lignification sets in in a number of circles, each surrounding a large internal vessel of this zone, and proceeds towards the vessel from all sides; often even in a very large and mature root one or more layers of cells immediately surrounding the vessel may be non-lignified.

The protoxylem elements also are frequently embedded in a cellulose-walled group of cells.

The Vessels.

The vessels of the xylem occur in radial groups with exarch protoxylem, having the normal arrangement for monocotyledonous roots. These are very often accompanied internally by large vessels scattered throughout the fibrous zone.

The external elements of the protoxylem are thickened in an annular manner (Pl. 49. fig. 46) and are generally lignified early. The vessels of the metaxylem are scalariformly thickened, as are also the large internally scattered vessels. These latter are frequently quite without lignification, even in the mature root, the wall giving a very different cellulose reaction with iodine and sulphuric acid.

The arrangement of the scalariformly marked areas is of the nature commonly met with in large roots of Monocotyledons and in large tracheids of ferns, but is here more regular than usual (Pl. 49. fig. 49).

In the large vessels the transverse walls marking the originally distinct elements from which the vessel is built up often partially persist, and in any case the vessel is constricted at these points, the whole structure when separated out by Schultze's macerating-fluid presenting a moniliform appearance.

The internal vessels are often very large, particularly in *Corypha umbraculifera* (Pl. 50. fig. 70).

In some cases they are closely packed and lateral pressure has led them to adopt a radially elliptic form instead of the usual circular outline.

The elements immediately surrounding one of these large vessels are sometimes marked in a scalariform manner in the same way as the vessel itself; these elements are expanded at the points of constriction of the vessel and fill the depression (fig. 49). A mass of deeply staining mucilaginous substance is often found in the vessels in the region of the partially disintegrated transverse walls.

In certain cases the transverse walls may be thickened and lignified in bands stretching across the end-plate; the rest of the end-plate may then disappear, leaving trabeculæ of lignified material extending across the cavity of the vessel.

Thylosis-formation is of very frequent occurrence in the larger vessels. This is particularly well shown in *Areca concinna* (Pl. 49. fig. 51) and *Cocos flexuosa* (Pl. 49.

fig. 50), where the development was traced and was found to follow the normal course, the surrounding parenchyma extending into the lumen of the vessel through the pits, and presenting the appearance of small rounded globules projecting freely; these are then cut off by a wall and undergo division, finally filling the vessel with a parenchymatous tissue, which may later become lignified and pitted.

The development of the vessels was traced in *Kentia* sp. and in *Areca* sp. They first appear as longitudinal rows of cells in the apex, a short distance behind the meristematic group. Each cell is of considerable diameter as compared with the surrounding elements, but is very shallow. Each is richly provided with protoplasm and has a large nucleus. Further back the individual elements of the strand are much elongated and the nucleus is beginning to disappear, while still further up the root the nucleus has quite gone, and the disintegrating protoplasmic contents have shrunk from the walls of the cells except the end walls. In a still older vessel the protoplasmic contents are greatly reduced and have passed into a dark-coloured mucilaginous mass at one or both ends of the cells near the transverse walls, whose dissolution takes place only very late in the development of the vessel, and may even be incomplete in the mature root.

In no case was there any trace of the origin of vessels by the breaking down of more than one cell in the lateral direction as described by T. G. Hill for *Dioscorea* (21).

The order of appearance of the vessels is centrifugal, the large scattered vessels when present being the first to appear in centrifugal order, followed in turn by the metaxylem and the protoxylem of the bundles, the last elements to develop being the external vessels of the protoxylem. Thus the Palms conform to the account given by Buscalioni (22) and Pirotta (24) for several Monocotyledons, and confirmed by T. G. Hill (21) in *Dioscorea*. Lignification of the xylem takes place in a centripetal direction.

Sieve-tubes.

The sieve-tubes are principally grouped together into phloem-bundles alternating radially with the protoxylem group. In *Latania Commersonii* (Pl. 50. fig. 72), however, they occur also in strands scattered throughout the fibrous zone among the large internal vessels. Phloem also occurs in a few roots in connection with the vessels in the medullary strands described below, and in *Iriartia*, as already mentioned, what appears to be an immature sieve-tube occupies the centre of each fibrous group in the cortex.

The sieve-tubes are generally rather large thin-walled elements with somewhat oblique sieve-plates. Very little callus was found in any of the tubes.

The companion-cells are thin-walled elements with tapering extremities.

Arrangement of Xylem and Phloem.

Some roots conform to the typical monocotyledonous type in having all the vessels arranged in definite bundles, with exarch xylem followed internally by a series of gradually increasing metaxylem elements. This is found in *Kentia Forsteriana* (Pl. 50. fig. 75) and *Sabal filamentosa* (Pl. 50. fig. 74).

More frequently, however, a series of internal vessels not referable to any particular xylem-groups is also present. In *Phœnix dactylifera* (Pl. 50. fig. 68) only a few of these are present; in *Phœnix sylvestris* (Pl. 50. fig. 73) there is a single irregular ring of them; in *Latania Commersonii* (Pl. 50. fig. 72) the number of internal elements is greatly increased and they are arranged in two or three irregular rings; while in *Raphia Hookeri* (Pl. 50. fig. 71) and *Corypha umbraculifera* (Pl. 50. fig. 70) they are closely packed and scattered throughout the whole of the fibrous zone, which here extends to the centre of the root, no pith being present.

Mohl (1) observed in *Diplothemium maritimum* and *Chamædorea elegans* that two peripheral xylem-groups might converge internally and abut on a single large internal vessel, thus forming a **V**-shaped structure, between the two arms of which might lie a phloem-group.

De Bary (6) described this phenomenon as follows:—"In thick root-bundles, some or all of the above xylem-plates converge in pairs in the form of a **V**, the groups of phloem lying inside a **V** are often smaller than those lying in between two **V**'s. The latter are frequently large radially placed plates, while the former are roundish groups. This occurs in an exquisite form in the aerial roots of an Aroid cultivated in Halle under the name of *Philodendron Imbe* and also in Palms. . . . . In *Chamædorea elegans* the irregularity goes further. In the corner of the **V** lies a small roundish group of phloem. Between every two **V**'s a similar group lies towards the outside, while further inside a second occurs which is elliptical in cross-section, and is separated from the outer group by interstitial sclerenchyma in which vessels frequently lie. Thus both an inner and an outer row of phloem-groups are present in the otherwise typical bundle."

Simple xylem **V**'s, between the arms of each of which lies a small phloem-group, are found in *Kentia Forsteriana* (Pl. 50. fig. 75) and *Livistona australis* (Pl. 50. fig. 61).

In *Raphia Hookeri* (Pl. 50. fig. 71) a further complication is found, a xylem **V** often embracing between its arms not a small phloem-group but a phloem **V**, which again embraces a xylem-group. In this species what may be described as xylem **Y**'s also occur, the external xylem-groups abutting in pairs internally on the outermost element of a radial series of two or more large vessels.

In *Heterospathe elata* (Pl. 50. fig. 73) this peculiarity is still more pronounced. Two xylem-groups approximate internally, forming a **V** just incomplete at its apex. Between the arms of this lies a phloem **V**, which in turn embraces a xylem **V**, and this again a small phloem-bundle. In this root the phloem **V**'s are sometimes incomplete, one limb being continuous with the phloem-group at the apex of the **V**, while the other is separated from it by an intervention of fibrous ground-tissue.

In *Raphia Hookeri* (Pl. 50. fig. 71) the phloem-groups extend centrally to a greater distance than usual, and in *Latania Commersonii* (fig. 72), as already mentioned, phloem-strands are distributed throughout the fibrous zone.

In *Phœnix sylvestris* (Pl. 50. fig 73) there is a greater development of xylem-vessels in the radial bundles than is usually found, the metaxylem consisting not of a single radial row of vessels, but of two or more rows.

In *Licuala gracilis* (Pl. 50. fig. 64) internally to, and in close connection with, the larger elements of the metaxylem occur several smaller elements, a point of considerable interest which will be dealt with below.

In *Ptychosperma filifera* (Pl. 50. fig. 65) the metaxylem forms tangentially extensive groups, from the peripheral surface of which extend as many as three protoxylem-groups. In this way a ring of xylem is formed in the periphery of the cylinder, with numerous but narrow interruptions.

In *Cyrtostachys Renda* (Pl. 50. fig. 62) a highly interesting condition is found in the presence of two or more xylem-groups, with inverted orientation, accompanied by phloem, the protoxylem being placed towards the centre of the root, lying in the internal portion of the fibrous ring. These xylem-groups are accompanied laterally by one or two phloem-groups.

A similar but less pronounced feature is seen in *Licuala gracilis* (Pl. 50. fig. 64). Here, however, the inverted xylem is not accompanied by phloem.

In *Latania Commersonii* (Pl. 50. fig. 72) the internal boundary of the fibrous zone abutting on the pith is irregularly lobed and in some of the lobes lies one of the large internal vessels.

In *Phœnix dactylifera* (Pl. 50. fig. 68) two lobes of the fibrous zone, each enclosing a vessel, project deeply into the pith.

In *Sabal glaucescens* (Pl. 50. fig. 67) a band of fibrous tissue extends completely across the pith and in this lie two vessels.

In *Livistona australis* (Pl. 50. fig. 66) a fibrous strand completely separated from the fibrous zone of the cylinder traverses the pith and contains a single vessel, while a similar strand in *Ptychospermum filifera* (Pl. 50. fig. 65) encloses two vessels.

In *Licuala gracilis* (Pl. 50. fig. 64) there are three medullary strands, two of which contain a number of vessels, the larger occupying the centre and the smaller ones radiating from these in a manner generally resembling the arrangement of vessels in a small pithless root—*i. e.*, an exarch radial arrangement of xylem.

In *Areca* sp. (Pl. 50. figs. 55 & 76) the presence of phloem-groups in the medullary strands alternating with the radial xylem-groups heightens the resemblance to a root-cylinder.

As the medullary strands are followed down the roots the number of vessels contained may decrease, but the strands remain as separate structures for a very long distance. In *Livistona australis* one was followed for 12·1 cms. without showing any sign of fusion with the fibrous zone.

JUNCTION OF BUNDLES OF ROOT AND STEM AND ESTABLISHMENT OF NORMAL ROOT-CYLINDER.

Mangin (9), in 1882, found that two distinct methods of junction of the bundles of adventitious roots with those of the stem occur in Monocotyledons. In the majority of forms the bundles of the root join on to a few of the outer bundles of the stem, or, in the case of large roots, on to a considerable number of peripheral stem-bundles. In the Palmaceæ and Pandanaceæ, however, connection is established not only with the peripheral stem-bundles, but also with others more deeply placed, the connecting strands being differentiated *in situ* in the ground-parenchyma of the stem.

In the present investigation the method of junction has been worked out in *Kentia* sp., *Latania borbonica*, and *Dictyosperma album*. In all these the phenomena presented are similar.

A transverse section taken through the stem in the region of connection shows a series of stem-bundles with internal scattered protoxylem followed externally by more densely packed metaxylem, and this in turn by the thin-walled phloem (Pl. **51.** fig. 89).

In the ground-tissue separating these bundles run strands of xylem and phloem pursuing a somewhat sinuous course and at their inner extremities establishing connection with the xylem and phloem of the stem-bundles, some of which are peripherally, some deeply placed (Pl. **51.** fig. 90). The xylem-elements of these strands are continued into the xylem-portion of the stem-bundles laterally and follow the course of this bundle as constituent elements of it.

In the same way the sieve-tubes pass into the phloem-portion of the stem-bundles (Pl. **51.** fig. 89).

These strands may be followed externally into the young root arising in the pericycle, as distinct procambial strands (Pl. **48.** fig. 1).

In transverse sections of mature roots close to the base (*i. e.*, just external to the pericycle of the stem), the centre is occupied by a number of free strands of fibrous tissue surrounding in the form of sheaths the xylem- and phloem-elements.

The xylem- and phloem-groups in each strand are radially arranged, with exarch protoxylem. Thus in this region, traversing the ground-parenchyma of the root, occurs not one but a series of cylinders each with a root-like structure.

The endodermis is not well-marked in this region of the root, but may sometimes be seen as an incomplete ring round several of the more external strands.

Some of the strands are very small and contain only a single xylem- and a single phloem-group (Pl. **51.** fig. 101). These are the individual bundles, each of which is proximally connected with a single bundle of the stem. Distally, by fusion with one another, they give rise to the radially symmetrical cylinders of this region of the root. The latter again in turn fuse with one another and give larger cylinders with irregular outline and irregularly arranged xylem and phloem. Usually the more peripheral cylinders are the first to fuse, the central ones often remaining as free strands even in the fully developed root. The peripheral cylinders by their fusion give rise to a series of incurved arcs as seen in transverse section, sometimes completed internally, when they enclose a central strand of ground-parenchyma continuous above with the common ground-tissue of the root (Pl. **51.** figs. 91 & 92).

By progressive fusion, the number of free strands becomes successively reduced in the more distal region. The closed rings of fused strands with central ground-tissue again open out internally and the edges fuse with those of neighbouring cylinders, and in this way a complete but deeply lobed ring is formed (Pl. **51.** figs. 94 & 98). This always remains longest incomplete on the adaxial side. The lobes become gradually more shallow in the distal region, until eventually a simple non-lobed central cylinder of normal root nature is established.

In most roots these changes in the vascular anatomy are completed in that portion of the root which is enclosed within the cortex of the stem; but in some cases, particularly in *Kentia* sp., *Areca* sp., *Areca Catechu*, *Areca concinna*, *Dypsis madagascarensis*, and *Iriartia* sp., the separate strands forming an incomplete central cylinder are continued often for a foot or more in the apical direction into the extracauline free portion of the root.

The endodermis is first clearly recognizable in a root showing the condition figured in Pl. **51.** fig. 91. Here the external surface of each of the arcs is provided with a lignified endodermal coating, which may be followed round towards the interior for a varying distance, but is eventually lost in the ground-tissue of the root. In a completely fused ring-like arrangement, such as that shown in Pl. **51.** fig. 90, the endodermis often nearly encircles it, but on the inner face of the ring it becomes indistinguishable from the cells of the ground-tissue.

In the cylinder referred to, and other similar strands, the arrangement of the xylem and phloem, though distinctly radial, is not quite regular, the protoxylem-groups of the internally orientated bundles being either absent or abnormally orientated, and the phloem-groups are often tangentially extended. In some cases, however, as in *Areca Catechu*, the endodermis forms a complete investment around one or more of the closed rings, and here the arrangement of xylem and phloem is radial and perfectly regular, as it is also in the case of *Areca* sp. (Pl. **50.** fig. 76).

The progressive union of the separate arcs distally is well shown in the figures of *Kentia* (Pl. **51.** figs. 95, 96, 97, & 98).

In Pl. **51.** fig. 95 the upper strand, *a*, is formed by the union of three originally distinct strands, the two lateral ones still possessing some of their internally orientated bundles, particularly the phloem-bundles; the central one has lost all trace of its internal bundles, except the large vessel which represents the internal metaxylem element of a bundle. This strand is reduced to a wedge of fibrous tissue with only the external bundles of the originally radial series remaining. Such wedge-formation is very common and will be referred to below. In the strand *b* (Pl. **51.** fig. 95) fusion of the arc by its internal edges has occurred and a strand of ground-parenchyma is enclosed. A small internally placed strand in which the xylem is reduced to a single central vessel surrounded by five small phloem-groups is seen in Pl. **51.** fig. 96 to join the strand *b*, which is becoming incomplete internally, and in Pl. **51.** fig. 97 has opened internally, the enclosed strand of parenchyma being thus again in communication internally with the ground-parenchyma.

In fig. 98 the ring of fibrous tissue formed by fusion of the strands is seen, but is still deeply lobed and is incomplete on the adaxial side. In such a stage as this the endodermis at the bottom of a depression in the fibrous ring may extend internally as a single plate of cells, or may be doubled (Pl. **49.** fig. 48).

The complete continuity of a "cortical" and "medullary" parenchyma through the gaps in the incomplete cylinder is shown in Pl. **51.** fig. 100, where it obviously is quite impossible to distinguish between them.

An unusual occurrence is illustrated in the annexed diagram. The closed cylinder of text-fig. 2 is not formed by the usual method of incurving and final coalescence of an apical meristematic procambial strand, but by the approximation of a central free strand which finally closes the gap in the arc, so completing the circle. The xylem-bundles of

Fig. 1.

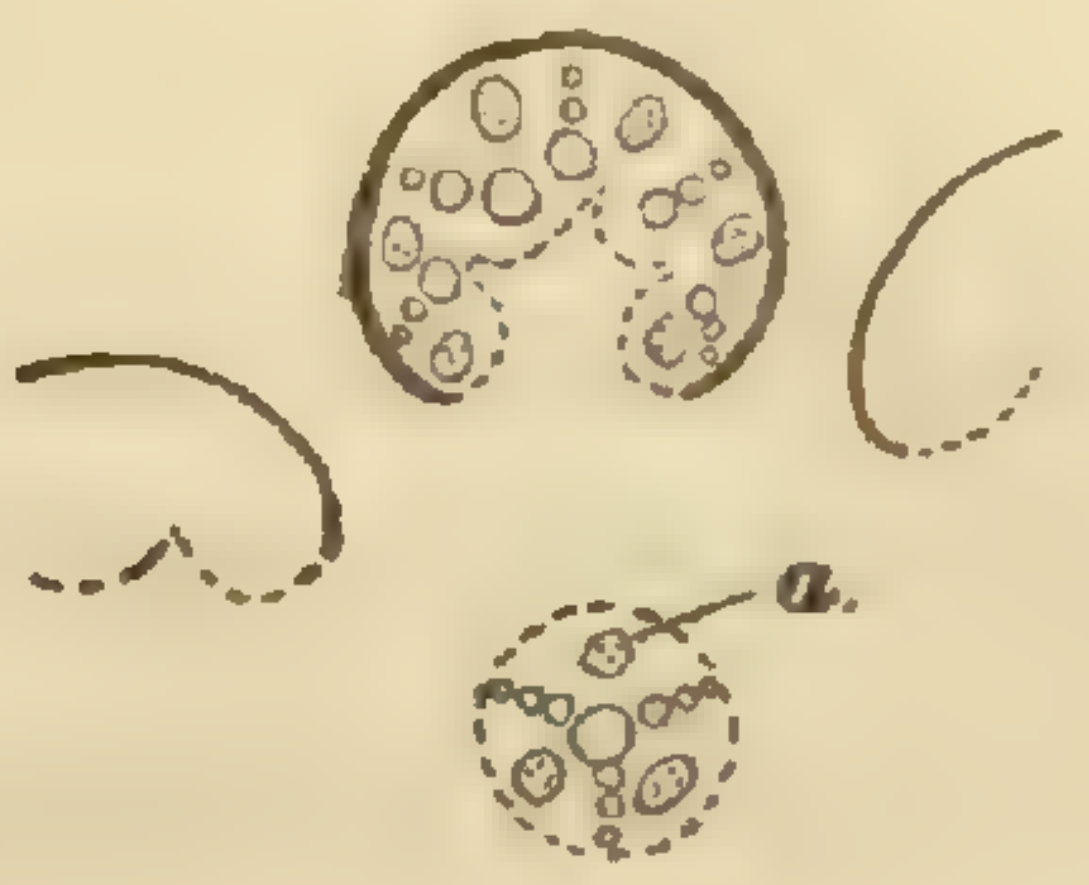
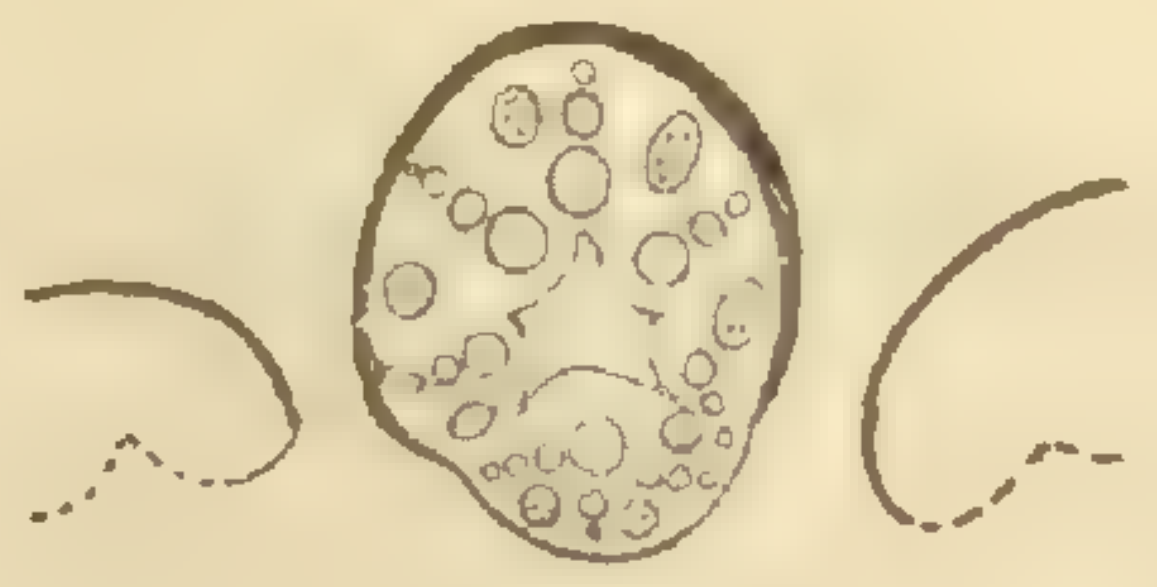


Fig. 2.



the strand are three in number and radiate from a common centre alternating with three phloem-groups. When fusion with the incurved arc takes place one of these phloem-groups (*a*) disappears, while the two xylem-bundles, originally orientated towards the exterior of the root, rotate internally as seen in text-fig. 2.

Another interesting case is shown in text-figs. 3, 4, 5, and 6. In fig. 3 a complete cylinder has been established somewhat externally to the general ring of arcs of fibrous tissue. Followed distally this ring opens out internally, and at the same time one of the fibrous wedges bounding the gap between the two arcs just internal to the ring under consideration breaks free and passes internally as a medullary strand, its vascular elements being reduced to a single central vessel (text-figs. 4 & 5). At the same time

Fig. 3.

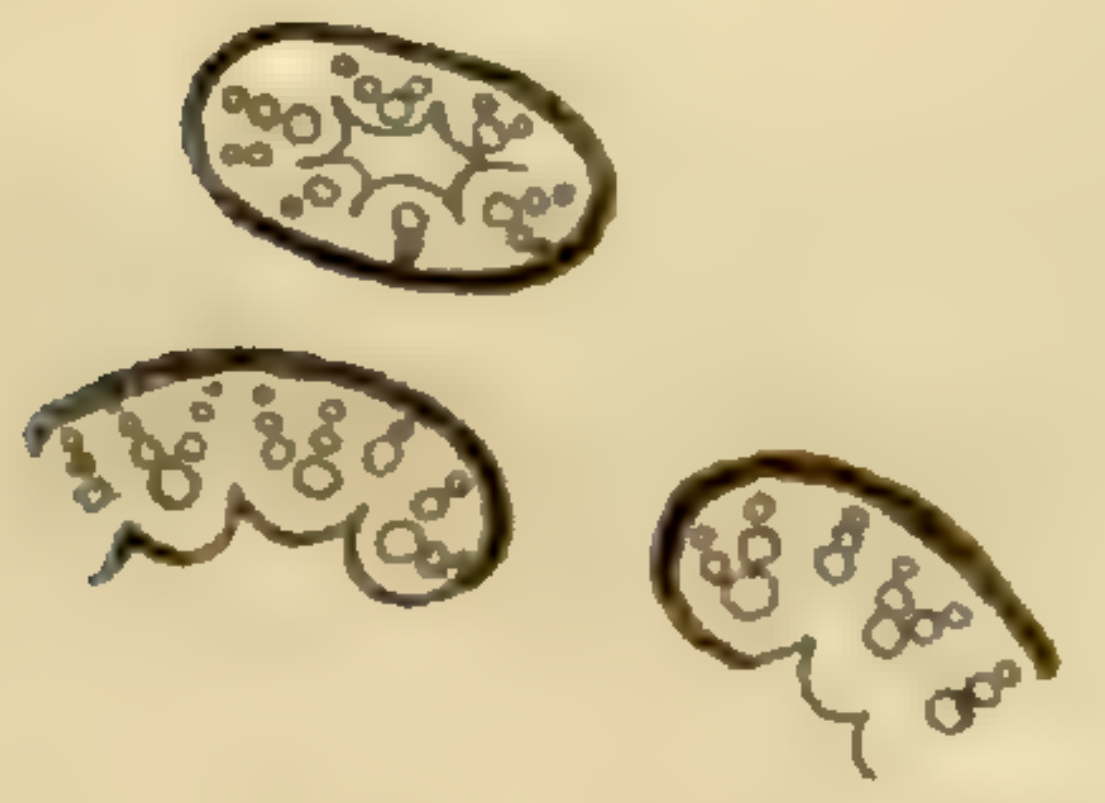


Fig. 4.

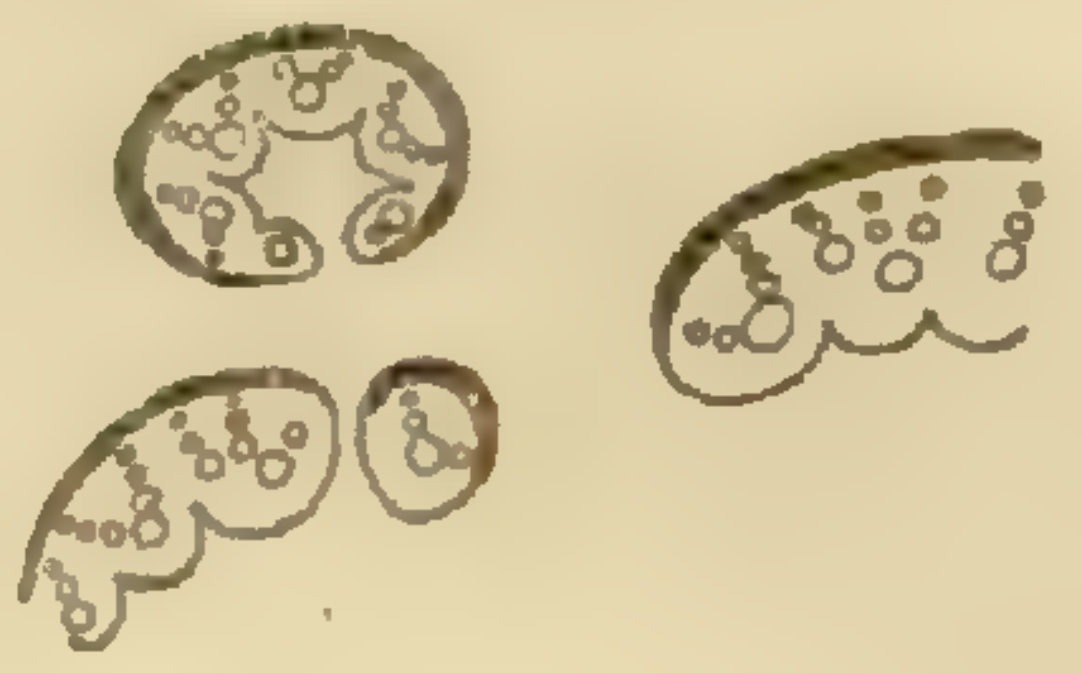


Fig. 5.

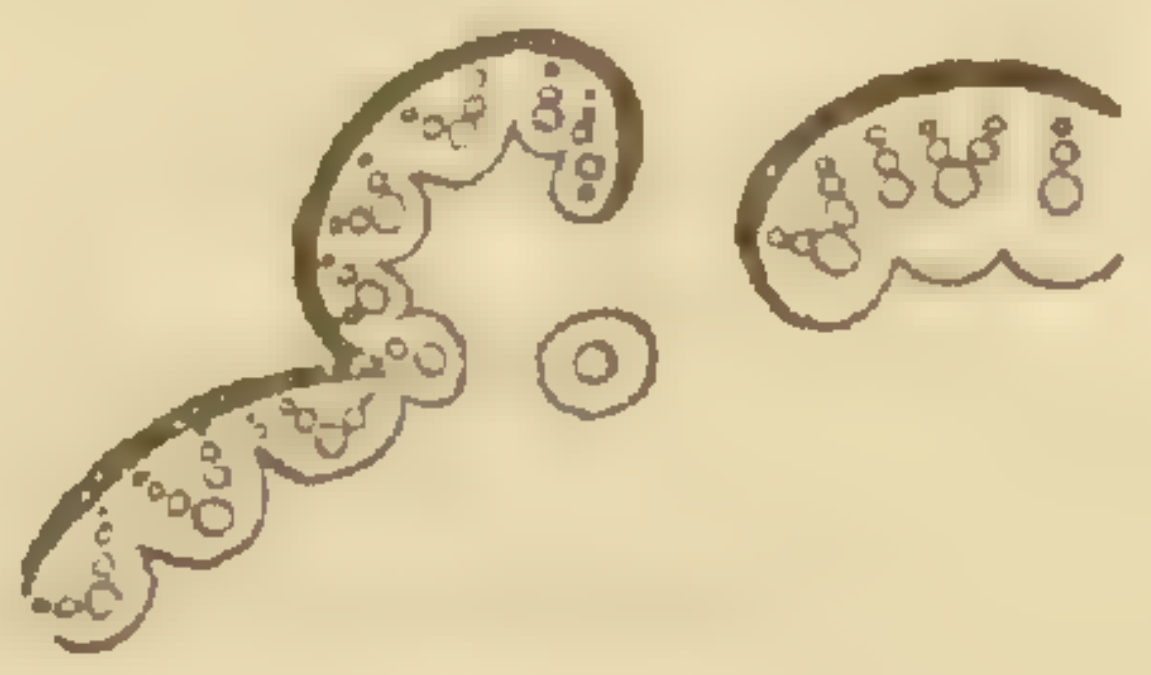
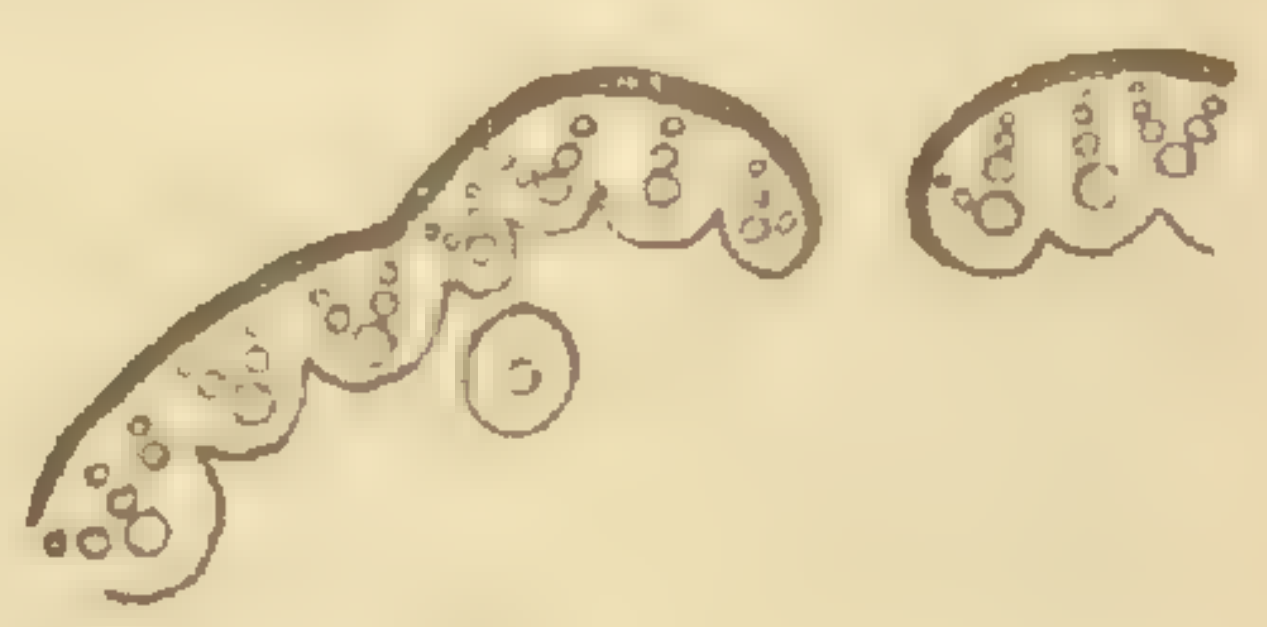


Fig. 6.



one edge of the internally opening ring establishes connection with the edge of the arc from which the medullary strand has become separated (text-fig. 6). This method of formation of a medullary strand is widely different from the usual method and has not been observed in any other case, the medullary strands being normally the reduced distal prolongations of the internal cylinders of the base of the root.

It has already been mentioned that generally the whole series of changes culminating in the formation of a normal complete central cylinder takes place in the intracauline portion of the root. This occurs, for instance, in *Latania borbonica*, and Pl. 51. fig. 102 shows the vascular cylinder of this species dissected out. The upper portion, which is enclosed in the cortex of the stem, is lobed, while the lower portion belonging to the external root is reduced to the normal condition.

Pl. 51. figs. 103 & 104 are from external portions of roots of *Kentia*. In fig. 104 the upper end shows a series of free strands which fuse below, resulting in a lobed cylinder.

A very curious appearance is presented in Pl. 51. fig. 105. The root appeared to dichotomize, and on dissection of the vascular cylinder this idea was strengthened as the partially separated strands are continuous, some into one section of the dichotomy, the rest into the other. Were there any trace of a blind ending of a principal root, the bifurcation would be explicable as resulting from two large lateral roots arising close to the end of the principal one of the nature of those in *Areca Catechu* (Pl. 51. fig. 116); but such an explanation is here quite without support, and dichotomy seems to afford the only satisfactory explanation of this peculiarity.

The structure of the series of sections represented by Pl. 50. figs. 55 & 76 may now be explained in the light of the facts established by the examination of *Kentia*, *Latania borbonica*, and *Dictyospermum album*. Each section represents the most complex condition met with in the *extracauline portion* of the root under consideration.

The section of *Areca* sp. (Pl. 50. fig. 76) illustrates the most complicated root-structure met with in the Palms. The original cylinders of the base of the root become united to form not a single ring, but three complete cylinders each enclosing a "pith" composed of ground-parenchyma, and a large incomplete cylinder whose internal portion is made up of three of the original strands each preserving its radial structure. The complete cylinders show the internal lobing of the fibrous ring in the form of wedges, each representing an originally separate strand from which the internal phloem has disappeared and also internal protoxylem, leaving only a large vessel, sometimes accompanied by one or more smaller elements, to represent the metaxylem of originally centrally orientated xylem-bundles.

In the incomplete cylinder in one case an internally directed protoxylem-group persists, and in several cases two or three of the metaxylem-elements of these bundles remain.

The radial symmetry of the fibrous groups forming the edges of the incomplete cylinder exhibit a nearly complete radial structure, which is also exhibited by the three strands forming the internal portion of this cylinder.

In the parenchymatous tissue lying within this cylinder the medullary groups show a mass of xylem with two or three radiating protoxylem-groups and the same number of phloem-groups, the original radial strands not having lost their primitive structure, as is usually the case with medullary strands.

In *Iriartia* (Pl. 50. fig. 55) the peripheral strands have united into a series of arcs, the internal lobing of which indicates the boundary of the originally free strands. The internal protoxylem-groups have aborted and generally also the phloem-groups, but in the segments forming the free edges of the arcs an internal phloem-group often persists. The medullary strands preserve their original radial symmetry, usually possessing two or three xylem-groups alternating with as many phloem-groups. The endodermis bounds each arc externally and is continued inwards round the edges for a short distance, but is soon lost as a definitely marked layer in the common ground-parenchyma.

Areca sp. (Pl. 50. fig. 56) is essentially similar to *Iriartia*, but the medullary strands have lost their phloem-groups. The wedge-shaped internal lobes of the fibrous tissue of the arcs are well-preserved and an internal phloem-group is commonly present in the lateral lobes of any arc.

In *Kentia* sp. (Pl. 50. fig. 57) the fusion of the arcs is somewhat further advanced. The wedges are still well-marked, but medullary strands are absent, all the original strands having apparently entered into the peripheral ring—a very uncommon occurrence. One of the strands composing the ring of arcs persists as a radially symmetrical cylinder. A similar thing occurs in another section of *Kentia* sp. (Pl. 50. fig. 59).

Dypsis madagascarensis (Pl. 50. fig. 58) shows much the same structure, but here medullary strands occur and the lateral fusion of the arcs is more extensive. An interesting peculiarity is evident in the small medullary strand *a*. It approximates very closely to the periphery of the ring, abutting on a gap between two arcs. This small strand is on its outer face provided with endodermal cells exactly like those outside the arcs. In this root also one peripheral strand retains its radial symmetry.

In *Areca* sp. (Pl. 50. fig. 60) the fusion of the arcs is much more extensive on one side of the root than on the other. The elements of the xylem-groups are more abundant than usual, and in some cases the larger internal vessels of the metaxylem are accompanied internally by smaller vessels which represent persistent traces of the internally directed xylem-groups of the radially symmetrical strands, the protoxylem of which has disappeared. A strand possessing two protoxylem-groups, one directed externally and one internally, is united with the inner extremity of a fibrous wedge of the peripheral system. A similar strand is found in *Cocos plumosa* (Pl. 50. fig. 61), but here the vascular elements are reduced to a single vessel as they are in most of the medullary strands. In one, however, the radial arrangement of four xylem-groups and four phloem-groups persists. The peripheral system forms a ring only incomplete on the adaxial side, and in the gap occurs a small strand like the one just described, but possessing five xylem- and phloem-groups.

Cyrtostachys Renda (Pl. 50. fig. 62) is of particular interest in retaining two of the internally directed xylem-groups of the original strands, accompanied by phloem laterally, and a third group of two vessels in another wedge representing the metaxylem-vessels of such a group whose protoxylem-elements have disappeared.

In the section of *Dypsis madagascarensis* (Pl. 50. fig. 63) the ring is only incomplete on the adaxial side. The wedges bounding the gap alone show internal phloem, and in one case internally directed protoxylem also.

In *Licuala gracilis* (Pl. 50. fig. 64) the ring is complete. In several cases the large metaxylem-elements are accompanied centrally by remains of the internally directed xylem, and in other cases a well-developed internal xylem-group persists. The three medullary strands show three stages in the normal reduction of these structures. One possesses a central vessel and two radiating protoxylem-groups. The second has lost its protoxylem, and the third only retains a single central vessel. Thus the fact that these medullary strands, which possess, as is usually the case, only a single central vessel, really represent reduced structures which had originally a radial arrangement of xylem, is here well illustrated, as is also the further fact that some of the large internally placed vessels of the fibrous zone are the metaxylem-elements of internally orientated xylem-bundles whose protoxylem has disappeared.

The rich development of metaxylem and its tangential extension in *Ptychosperma filifera* (Pl. 50. fig. 65) have been already described, as has also the abundant V-formation in *Livistona australis* (Pl. 50. fig. 66). It may here be noted that

V-formation is now explicable as due to the persistence of two of the radiating xylem-groups of the original strand instead of the one which usually alone persists.

Double V-formation, such as obtains in *Heterospathe elata* (Pl. 50. fig. 69), is entirely explicable in the same way. Thus in the group on the left of the figure we are probably dealing with four xylem-groups, two of which had originally had an internal orientation, but which became outwardly directed when fusion of the strand into the peripheral ring occurred. That such an alteration in orientation may occur has been already observed for *Kentia*, where the outward orientation of two xylem-groups becomes reversed on fusion of the strand with the peripheral arc (p. 446, figs. 1 & 2).

The interest of the sections of *Sabal glaucescens* (Pl. 50. fig. 67) and *Phœnix dactylifera* (Pl. 50. fig. 68) attaches chiefly to the medullary strands, which have already received attention.

In *Corypha umbraculifera* (Pl. 50. fig. 70) the internal vessels are extremely large and occupy almost the whole of the centre of the root, no pith being present.

The same condition is found in *Raphia Hookeri* (Pl. 50. fig. 71), but to a less extent. These large internal vessels almost certainly represent the metaxylem-elements of the central strands whose protoxylem has disappeared and are thus comparable with the large vessels of the medullary strands of most roots.

In *Latania Commersonii* (Pl. 50. fig. 72) a similar abundant development of large vessels occurs, but a central pith is here present. A further point of great interest lies in the fact that phloem-groups of the internal strands have here persisted, and appear as phloem-bundles scattered throughout the fibrous zone amongst the large internal vessels.

In *Phœnix sylvestris* (Pl. 50. fig. 73) the internal vessels are reduced to a single ring, while in *Sabal filamentosa* (Pl. 50. fig. 74) no vessels occur which cannot with considerable certainty be allotted to the same original strands as those to which the protoxylem-groups belong, while this is still further evident in the perfectly normal root of *Kentia Forsteriana* (fig. 75).

In Pl. 50. figs. 77 to 88 a diagrammatic *résumé* of the changes which take place in the root is presented.

In Pl. 50. fig. 77 the series of cylinders each with a number of exarch xylem-groups is seen scattered throughout the ground-parenchyma of the base of the root. Each cylinder shows a root-like structure with alternating xylem- and phloem-groups.

In Pl. 50. fig. 78 fusion of the peripheral cylinders has commenced, and in Pl. 50. fig. 79 reduction of the internally directed xylem-groups has set in, with disappearance of internal phloem.

The protoxylem-elements of the bundles in the medullary strands which are formed by those cylinders which do not enter into the peripheral system have aborted, but the phloem still persists.

In Pl. 50. fig. 80 the fusion is incomplete only at one point, and the internal xylem is represented only by the large metaxylem-elements. Reduction of the xylem and phloem of the medullary strands has progressed still further than in Pl. 50. fig. 79.

In Pl. 50. fig. 81 the peripheral ring is complete, and shows only a depression on one side where the last fusion has occurred. The wedge-shaped internal projections of the fibrous ring still mark the limits of the originally free cylinders.

In Pl. 50. fig. 82 the root-cylinder is normal and the internal boundary of the fibrous ring, though sinuous, has lost its wedge-shaped projections. The medullary strands now each contain only a single vessel. The scattered internal vessels of the fibrous zone represent the metaxylem-elements of the internally orientated xylem-groups.

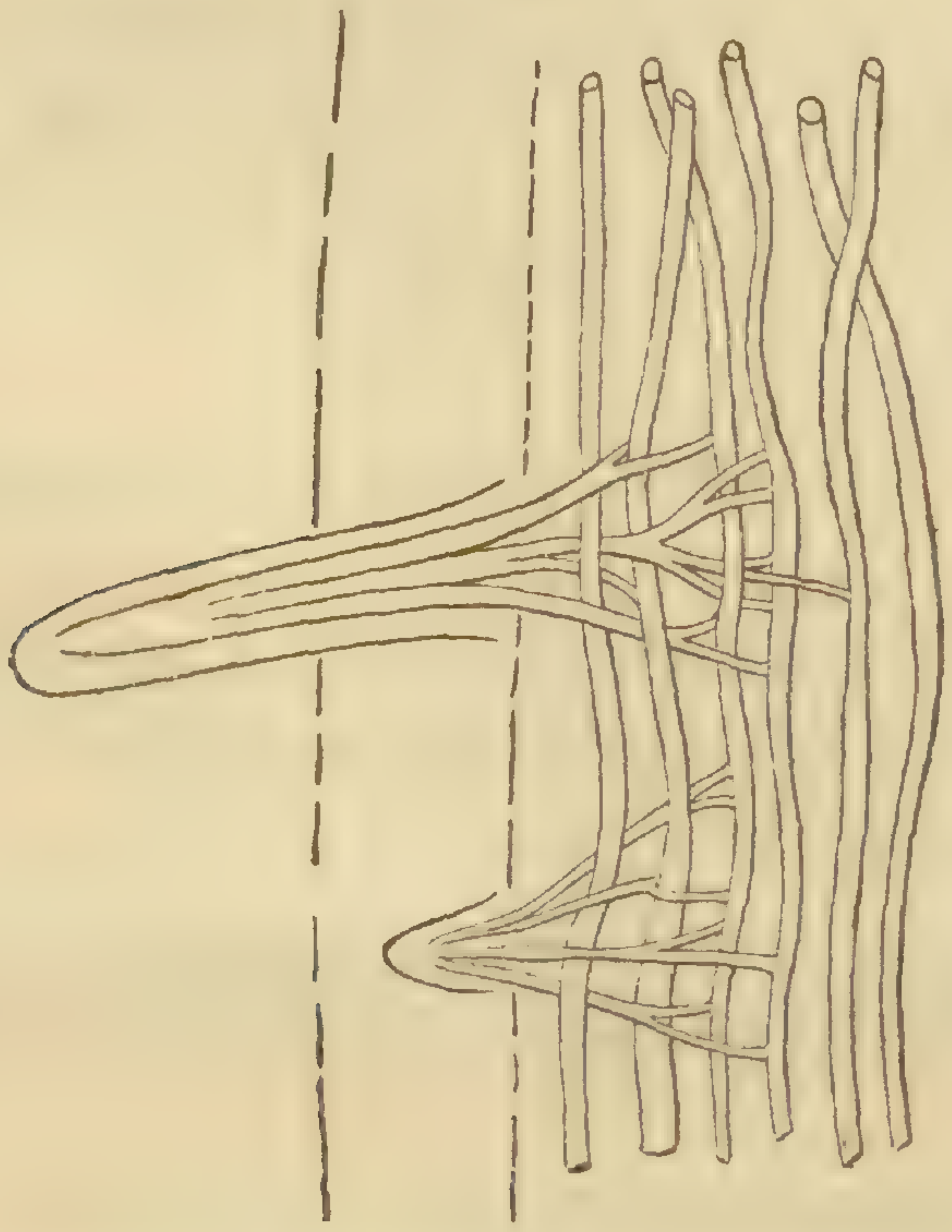
Sometimes the fusion of the cylinders of Pl. 50. fig. 77 takes place in a different manner. Instead of peripheral cylinders only fusing, fusion may involve some of the more internal cylinders also, as in Pl. 50. fig. 83. In this way the inrolled arcs of so many palm-roots are produced. Internal fusion of the edges of these arcs leads to the formation of cylinders enclosing parenchymatous ground-tissue, one of which is shown in Pl. 50. fig. 84 and a second in Pl. 50. fig. 85. Thus Cormack's "polystelic" structure is realized. While this has been progressing the internal protoxylem-groups have been disappearing, leaving only the large metaxylem-elements.

Distally these closed rings open out internally and the enclosed parenchyma is again in direct continuity with the common ground-parenchyma. Fusion of the edges of adjacent arcs now occurs, leading to the formation of a lobed ring, at first incomplete on the adaxial side, but later fusing here also.

Complete rounding of the external surface of the root-cylinder now occurs accompanied by loss of the internal wedge-formations, and thus normal root-structure is attained (Pl. 50. fig. 82).

The accompanying text-figure (7) illustrates the method of union of root and stem.

Fig. 7.



Lateral Rootlets.

The small lateral rootlets of the Palms, such as those shown in Pl. 48. fig. 11, *a*, have a perfectly normal origin in the pericycle of the relatively main root. The endodermis is ruptured and the cortex of the lateral root attains considerable thickness during its passage outwards. The endodermis is connected at its origin with that of the cylinder of the relatively main root (Pl. 51. fig. 106). The xylem- and phloem-bundles establish connection with several bundles of the parent root. In many cases it was found that an incomplete (Pl. 51. fig. 106) or complete cylinder of the peripheral system of strands in the central cylinder of the root might function as a normal root-cylinder in giving rise to lateral roots.

In *Areca Catechu* two forms of lateral roots were found (Pl. 51. fig. 111)—the normal small roots passing directly outwards, and also roots with much more extensive origin, which run obliquely outwards and downwards through the cortex of the parent root, but, curiously enough, very seldom reach the periphery, undergoing degeneration during their passage outwards; even when they do reach the periphery they usually cease to grow and soon abort. The connection of such rootlet with the cylinder of the parent root is seen in Pl. 51. fig. 107, where the ruptured endodermis of the main root is shown and its connection with that of the lateral root.

A section taken a short distance above this shows the upward extension of the xylem- and phloem-bundles of the lateral root inside the endodermis of the parent root. Here and there the phloem-groups of the two are still separate, and in the xylem-groups the protoxylem occupies a position between the metaxylem of the main root and the upwardly extended xylem of the lateral root.

The deep penetration of the xylem-elements of the lateral root amongst those of the parent root first mentioned by Hugo von Mohl (1) is shown in Pl. 51. fig. 118. The protoxylem of the lateral root (*ptxy.* 2) occupies the periphery of the cylinder lying just beneath the pericycle, that of the parent root (*ptxy.* 1) lying much more internally. Elements from the lateral root are seen penetrating centrally as far as, and even beyond, the innermost metaxylem-element. The phloem-group shows the small-celled protophloem (*ptph.*) surrounded by the metaphloem, that lying internally belonging to the main root, that externally to the lateral root. Lower down a section shows the cylinders of lateral and parent roots quite separate from each other, that of the former being lobed and internally composed of separate strands (Pl. 51. fig. 108). More distally the cortex of the lateral root is well differentiated, showing the dense outer layers and the parenchymatous inner zone with its large air-spaces, the whole being still embedded in the cortex of the parent root (Pl. 51. fig. 109). Further down, the cylinder of the lateral root attains a normal structure (Pl. 51. fig. 110).

In *Areca concinna* these larger internal roots may project for some distance beyond the parent root (Pl. 51. fig. 111), but this is apparently an unusual feature.

Fig. 8.

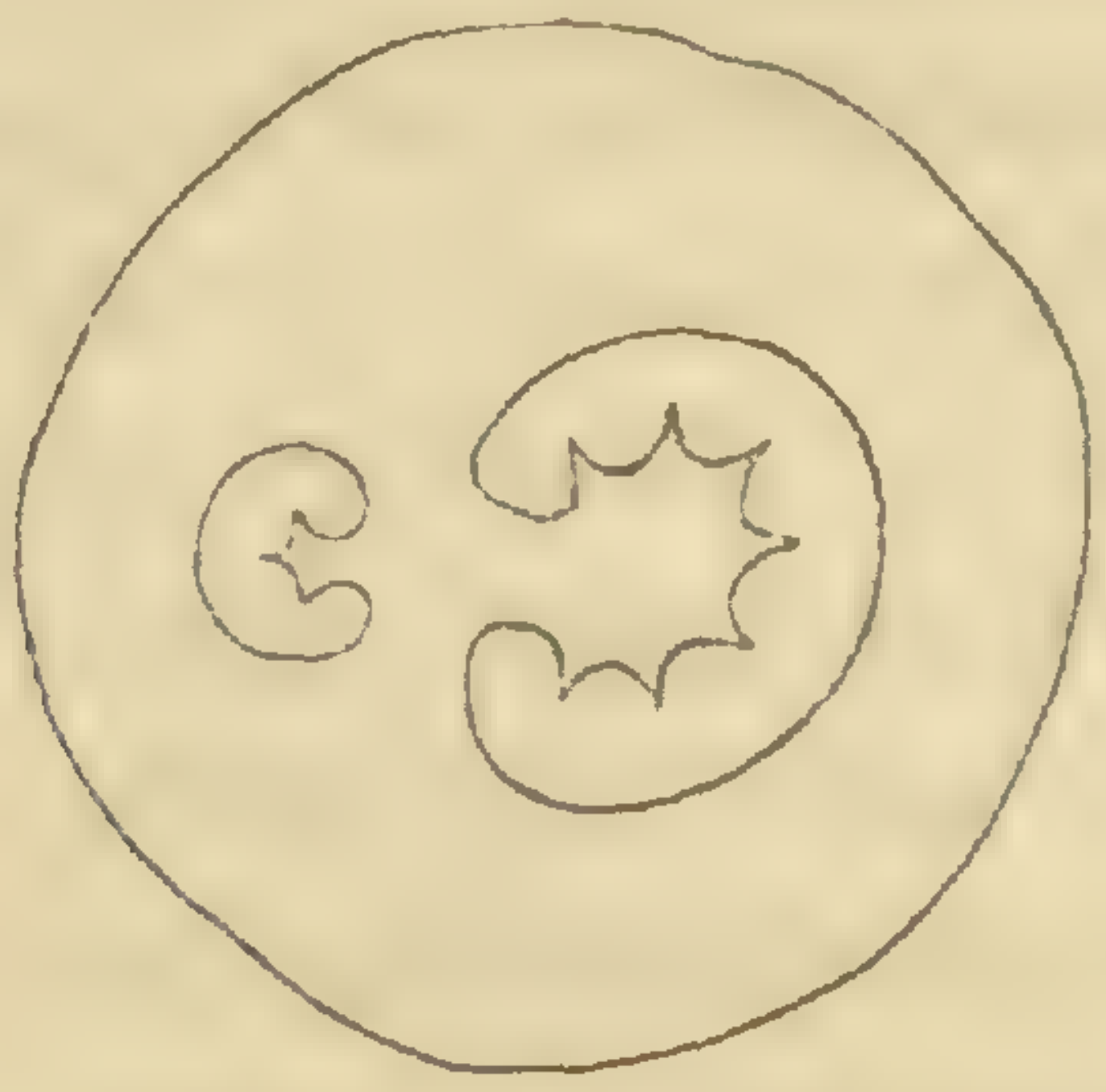
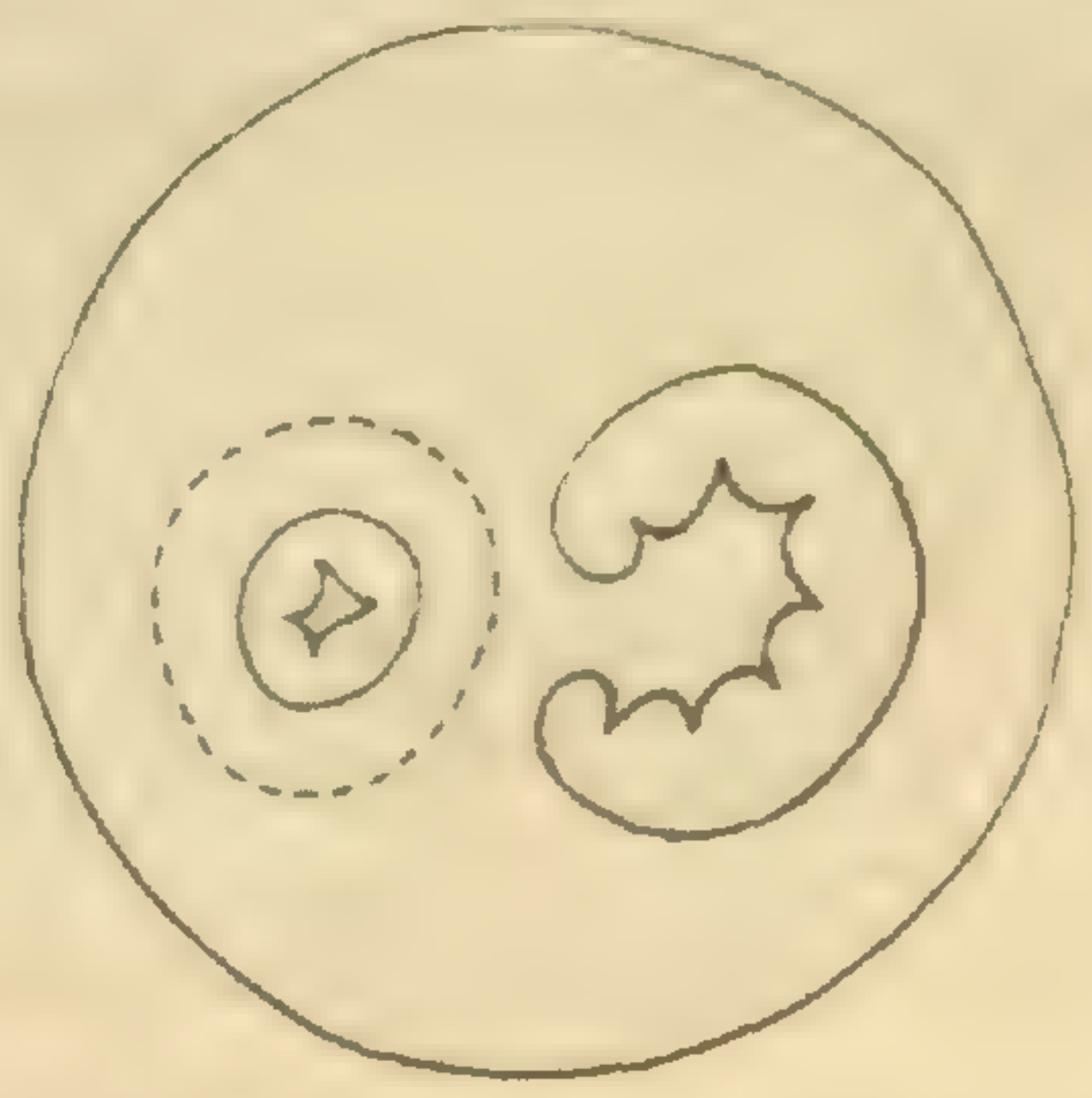


Fig. 9.



In *Areca concinna* a striking peculiarity is shown in the accompanying diagrams (text-figs. 8 & 9), where the cylinder of the lateral root in leaving that of the parent forms a root-gap which persists for some time, being still open when the cylinder of the lateral root has become complete.

Through the cortex of the extremities of some roots of *Areca Catechu* break many large lateral roots, giving to this region a swollen and irregular appearance (Pl. **51.** fig. 114).

In some cases the growing-point of the parent root aborts, and one or more of the large lateral roots grow downwards and continue growth in the direction of the parent. Two lateral roots are seen doing this in *Areca Catechu* (Pl. **51.** fig. 116).

A better example of the same thing is illustrated for *Actinorhytis Calapparia* in Pl. **51.** fig. 117, where the downwardly growing portion *a* is a large lateral root proceeding from the main root *b*, the other large lateral roots at *c* ceasing to elongate.

Iriartia presents one of the few known examples of spiny roots, and is referred to by Goebel in his 'Organographie.' Pl. **51.** fig. 112 illustrates a large aerial root arising from the slender stem. The lateral rootlets are all reduced to short spines, which present a curious internal structure. The outer layers of the cortex are parenchymatous, as are also the inner, but between these two zones occurs a lignified sclerenchymatous ring (Pl. **51.** fig. 113). The parenchymatous elements just inside this ring show clear evidence of secondary division, having quite a cambiform appearance (fig. 115).

The central cylinder of the spiny rootlet is bilobed, but otherwise it is normal in structure.

The well-known contractile nature of the roots of Palms is splendidly shown in certain roots of *Corypha umbraculifera*; a small portion of one of these is figured in Pl. **51.** fig. 120.

THEORETICAL CONCLUSIONS.

One result of the examination of the roots of Palms has been to show that the central cylinder in these organs is not the simple structure which Van Tieghem considered the root-cylinder to be, and upon which he based his conception of monostely.

The base of the root is occupied by a number of separate cylinders, each essentially "stele"-like in structure, as evidenced by the presence of regularly-arranged strands of xylem and phloem embedded in the fibrous ground-tissue of the cylinder, although no definitely marked endodermis is present.

Any objection to the term "stele" as applied to these cylinders, based upon the apparent absence of an endodermis, loses much of its force in view of Strasburger's demonstration that the histologically differentiated endodermis, even when present, does not always represent the innermost cortical layer, but may occur in any zone, while the first "extra-stelar" layer may differ in no respect from the ordinary ground-parenchyma.

The base of the root would therefore be termed, in the language of the stelar theory, "polystelic," and the normal root-cylinder, formed as it is by the fusion distally of the proximally free "steles," would be "gamostelic"—truly a curious result.

Cormack's "polystely," likewise produced by fusion distally of the free "steles," would be termed "gamostely"—a number of "gamosteles" traversing the ground-parenchyma.

If, however, it be still urged that a histologically differentiated endodermis is necessary for the constitution of a "stele," then if the cylinders of the base of the root, which, it must be remembered, extend in all cases into the apices of the young roots and often into the apices of older roots also as separate procambial strands, be not "steles," may they be termed "bundles"?

De Bary regarded the central cylinder of the normal root as a single bundle, and stated further: "In the thick roots of Pandanaceæ and the genus of palms, *Iriartia*, there are found a number of parallel bundles which converge at the growing point." His further remark, "it may be doubted whether these should be called parts of one very large divided bundle or so many individual bundles," does not concern us here.

If, then, these strands at the base of the root are bundles, the root is "polydesmic" in this region, an interpretation leading to the result that the normal cylinder produced distally is "gamodesmic," unless here again an endodermis surrounding each bundle be considered necessary for true "polydesmic" nature.

If such an investment be considered necessary, then the only conclusion to be drawn would appear to be that the root in its basal portion is purely "astelic," a "meristelic" interpretation being out of court, since at no previous stage has any stelar structure been present, "meristeles" being the result of the splitting of a "stele."

Fusion of the separate strands distally, giving rise to series of arcs of fibro-vascular tissue, provided on their peripheral surfaces with an endodermal layer, leaves the root still in an astelic condition, often retained even in very long roots of certain palms, but usually giving place distally, by further fusion of the arcs, to a typical root-cylinder surrounded by a complete endodermal investment. In this state the root might be described as locally monostelic for purely descriptive purposes, without any reference to the real mode of origin and relationship of its constituent parts. It is at least doubtful, however, whether Van Tieghem's conception of "monostely" is here attained, the "monostele" in the present case being the result of a gradual change from an "astelic" condition.

The stelar theory thus failing to explain satisfactorily the conditions met with in palm-roots, it becomes of interest to see how far Hanstein's idea of the root as composed of several independent zones arising from as many individual initial layers at the apex will here hold good.

It has been already mentioned that in the apices examined (namely, those of *Kentia* sp. and *Areca* sp.) stratification is entirely absent, the apex in each case possessing a common group of initial cells, by division of which the ground-parenchyma of the root is formed. A short distance behind the apex the procambial tissue, from which the fibro-vascular elements are developed, appears in the ground-parenchyma, and any distinction of Hanstein's initial layer is quite wanting.

It is possible to extend this conception to include the structure in many other cases, among which may be mentioned the non-stratified root-apices of the Papilionaceæ, described by Janczewski; stem-apices of the Pteridophyta, occupied by a single initial cell or group of cells, which by division gives rise to a common ground-parenchyma, wherein arises the procambial tissue, in the so-called "polystelic" forms, each procambial strand being the precursor of a "stele."

The work of Tansley and Boodle shows that great irregularity exists in the development of these so-called "steles," a single cell sometimes giving rise on division to both "extra-stelar" and "intra-stelar" tissue.

Important evidence has recently come to hand in a memoir by Schoute, entitled 'Die Stelär-Theorie,' where he shows that even in the stratified apices of Phanerogams no hard-and-fast line can be drawn between the products of the various layers.

It thus becomes more and more evident that both in stem and root we have to deal with a common parenchymatous ground-tissue, through which run strands of xylem and phloem, usually accompanied by fibrous tissue, often in the form of sheaths—xylem, phloem, and fibres being all developed from the procambial tissue. This last sometimes arises in the form of separate strands in the stems of so-called "polystelic" Pteridophyta and in stems of Dicotyledons and Monocotyledons, each strand giving rise in the former case to a "stele" and in the latter case to a "bundle." Thus it appears that the "bundle" in a dicotyledonous stem and the "stele" in a "polystelic" fern arise in a precisely similar manner, whereas the "stele" of a dicotyledonous plant and the "stele" of a "polystelic" fern are, from the developmental standpoint, very different structures.

In other cases the procambial tissue takes the form of a single central strand, as in "pithless" roots and "protostelic" ferns, or of a hollow cylinder in roots with pith, while in yet other cases—for example, the roots of Palms—it may at first appear as separate strands, giving place later to a hollow cylinder.

It remains to be seen how far the results of future investigation will support the views expressed above, but at the present time there is great weight of evidence tending to show that all ideas of "monostely" and "polystely," and of "medulla" and "cortex" as separate morphological entities, are founded upon an artifical conception of the nature of the structures involved.

My thanks are due to the Director of the Royal Gardens, Kew; to the Director of the Royal Botanic Gardens, Ceylon; to Mr. Herbert Wright; to Professor Bower; and to Professor F. W. Oliver for the material on which the present investigation has been carried out; and particularly to Professor Farmer for his kind and unfailing interest and valuable criticism during the progress of the work.

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DESCRIPTION OF INDIVIDUAL SPECIES.

In the order of the following descriptions, Drude's arrangement, as given in Engler and Prantl's 'Pflanzenfamilien,' has been adopted.

I. Coryphinæ.

(1) Phœnix reclinata, Jacq.

The limiting-layer is composed of slightly lignified cells, almost isodiametric as seen in transverse section, but about twice as long in longitudinal section. The walls, except the inner tangential, are considerably thickened, and the outer extremities project slightly as small papillæ. Succeeding these is a layer, some fourteen elements in depth, made up of elongated cells more or less fibrous in appearance, but generally with squared ends. These cells are slightly lignified, while here and there occurs an element much more strongly so. Then follows a zone, six elements in depth, of elongate lignified fibres with simple pits.

The internal cortex is composed of parenchymatous cells with large radially extending air-spaces. The cells of the innermost portion of the cortex immediately surrounding the endodermis are more closely packed and tangentially compressed. Embedded in the inner cortex are bundles of strongly lignified fibres, with small lumina and simple small pits. The endodermis is generally well lignified and thickened on all its walls, except the outer tangential. The inner tangential walls may be so greatly thickened as to bring about almost total occlusion of the lumina. In the fully mature root not a single passage-cell was observed. The pericycle, usually two cells in thickness, is, in the mature root, lignified and pitted, the lignification being most strongly developed opposite the protophloem.

A thick zone of schlerenchyma, in which lie the xylem- and phloem-groups, surrounds a central irregular medulla. The vessels of the protoxylem are lignified and surrounded by a mass of small-celled parenchyma. The lignification decreases as we follow the metaxlyem centripetally, and in the large inner vessels it may be wanting altogether, the original cellulose walls remaining unaltered. The layer of cells abutting directly on these large vessels is frequently parenchymatous, the elements having cellulose walls. Often two protoxylem-groups are found in connection with one large inner vessel, resulting in the V arrangement, the arms embracing a phloem-group.

The medulla is parenchymatous. Into it may project one or more masses of the lignified sclerenchyma which encloses it, each mass containing a large vessel, but no separate sclerenchyma-strands were observed in the medulla.

(2) PHŒNIX ZEYLANICA, Trimen.

This root is very similar to the last in all essential characters; the medulla is, however, much smaller, the sclerenchymatous zone of the central cylinder extending almost to the centre of the root. The vessels are confined to the periphery of this zone.

(3) PHŒNIX SYLVESTRIS, Roxb.

The limiting-layer is cuticularized and lignified. Then comes a cuticularized and slightly lignified zone of about four cells in depth. These elements are parenchymatous and about twice as long as broad. Then follow two or three layers of thin-walled cellulose parenchyma, followed internally by lignified fibres. The outer portion of the inner cortex is composed of parenchymatous cells only. This is succeeded by a broad zone, with large air-spaces and bundles of fibres enclosed in a sheath of stegmata as in *Ph. reclinata*, Jacq. The groups of fibres are here seen to become lignified from the exterior towards the interior. The innermost layers of cortex are as in *Ph. reclinata.*

The endodermis consists principally of thin-walled cells slightly lignified, but non-lignified cells may occur at any point, as frequently opposite the protophloem as opposite the protoxylem. In longitudinal section the endodermic cells are seen to be from two to three times as long as broad. The pericycle is entirely non-lignified, consisting of ordinary cellulose parenchyma. Opposite the protoxylem it may be wanting entirely, so that the external protoxylem-elements abut directly on the endodermis. Opposite the protophloem the pericycle expands and is here two or three elements in depth.

The protoxylem and protophloem are enclosed in parenchymatous tissue. The remaining ground-tissue of the central cylinder, excepting a small central pith whose limits are not well defined, consists of sclerenchyma, in which are embedded the phloem- and xylem-vessels. The vessel-walls are generally well lignified, but in some of the innermost vessels they may still retain their cellulose nature.

The small irregular central medulla is parenchymatous and surrounds a central air-space.

(4) PHŒNIX DACTYLIFERA, Linn.

The limiting and next three layers are more or less cuticularized and non-lignified. Then follows a lignified zone of elements, some six or seven elements in depth and of the usual elongated type. The inner cortex is composed of parenchyma, with large air-spaces of no great radial extent, arranged in many irregular zones, and of bundles of fibres with their accompanying stegmata.

The endodermic cells are lignified and very greatly thickened, except on the outer tangential walls, the lumina being nearly occluded.

The endodermic cells are four or five times longer than broad, and the thickening is of that nature described by Mohl as "fibrous."

No passage-cells were observed. The pericycle consists of elongated, square-ended, lignified cells. A small group of cellulose-walled parenchyma surrounds each protoxylem-group.

A broad zone of sclerenchyma encloses the pith, and in this are embedded the xylem-vessels and the phloem. The protoxylem is lignified, but the inner vessels usually retain their cellulose walls. Two or more protoxylem-groups often abut on one large vessel, and internally are irregularly arranged large vessels which do not appear to belong to any xylem-group. These latter are embedded in masses of lignified ground-tissue, on the peripheral side continuous with the sclerenchymatous zone, but internally projecting into the medulla.

The medulla is parenchymatous, with a few air-spaces. Between the internally projecting sclerenchymatous masses the cells of the medulla are considerably crushed, showing that a differential rate of growth has taken place between the medullary cells and the sclerenchymatous masses in these regions.

(5) ACANTHORHIZA ACULEATA, H. Wendl.

The limiting-layer is of the usual type. The underlying zone of lignified elongated elements shows clearly that lignification commences in the external layer, and shortly afterwards appears also in the internal layer. It then proceeds centripetally and centrifugally, and in the mature root leaves only one or two layers of cells non-lignified in the middle of the sclerenchymatous zone. Interior to this zone comes the inner cortex, the outer part of which is composed of closely packed and slightly lignified cells. This portion of the cortex is relatively much wider than usual. The internal zone of the inner cortex with its air-spaces follows. The air-spaces are irregular and comparatively small, and usually separated only by a single layer of cells. In this region the only strengthening elements are short, square-ended, not greatly thickened, parenchymatous cells.

The endodermis is of the usual lignified type.

The pericycle is two cell-layers in thickness.

The sclerenchymatous zone is well developed and composed of densely lignified and thickened elements. In the centre is a parenchymatous pith.

The sclerenchymatous ring is lobed internally, rays of the pith extending in an outward direction between the wedge-shaped lobes of sclerenchyma. There is only one irregular ring of large vessels, and these are placed very peripherally. They are fewer in number than the protoxylem-groups, and hence **V**-formation is general.

(6) THRINAX PARVIFLORA, Sw.

In the young root the limiting-layer is lignified, as are also the subperipheral layers of elongated cells, these latter being also slightly cuticularized. The greater part of the cortex consists of ordinary parenchyma with no fibres. There are very large, radially extended air-spaces, with occasionally a thin tangential diaphragm of cells. These cavities extend to within one or two cells of the endodermis. The endodermal cells are lignified and "fibrously thickened" on all but the outer tangential walls. The pericycle is generally only one cell in thickness, and is followed by the broad sclerenchymatous zone in which the xylem-vessels and the phloem are embedded.

The vessels of the protoxylem are lignified, but the larger internal vessels are not. These latter vessels do not extend far centrally. **V**'s are formed embracing the phloem. In the centre is a small parenchymatous pith.

The older roots are extremely hard, lignification being very extensive and the elements very small and closely packed. The outer portion of the cortex is made up of elongated elements with almost totally occluded lumina, with irregular radial rows of thinner-walled elements, along which the sections invariably split in cutting. This zone is succeeded by a parenchymatous cortex with very irregular air-spaces and a large proportion of lignified, thick-walled, pitted parenchyma. The endodermic cells are greatly thickened and lignified on all the walls. The pericycle is lignified and is two cells in thickness.

The sclerenchyma enclosing the xylem- and phloem-elements is greatly sclerozed and pitted. There is no pith, but in many cases the centre of the root is occupied by a cavity, the walls of which are blackened as though diseased. The xylem-plates extend a considerable distance centrally, and occasionally a **V** is formed. All the vessels are lignified.

The phloem-bundles show considerable radial extension.

(7) THRINAX EXCELSA, Lodd.

A distal portion of the root shows a limiting-layer of thin-walled lignified cells, nearly exfoliated. Underneath this are many layers of somewhat lignified, elongated cells. The parenchymatous inner cortex has irregular air-spaces and lignified, fibrous, pitted cells. The innermost portion of the cortex is made up of smaller, more tightly packed cells, without air-spaces, but with many lignified fibres. The endodermis is lignified, and the cells much thickened on all except the outer tangential walls. They are considerably elongated and the thickening is of a "fibrous" nature.

The pericycle comprises one or two layers of lignified pitted cells. The xylem-plates and the phloem are embedded in a sclerenchymatous zone. The xylem forms very wide V's, and internally are vessels that appear to have no relation to the xylem-plates. There is a small pith, chiefly occupied by two strands of sclerenchyma, connected externally with the sclerenchyma-zone. In the centre of each is a single vessel.

In a more proximal portion of the root the outer subperipheral elements are separated from those more internally placed by several layers of unaltered parenchymatous cells. This means that the centripetally proceeding lignification has not yet met that proceeding centrifugally.

The internal cortex, as in the more distal region, contains very irregular air-spaces and many fibres scattered singly.

On one side of the central cylinder the sclerenchymatous zone is interrupted, and at the same point the endodermis, instead of completing the circle, dips in very deeply, forming a groove occupied by cortical ground-tissue. Down the sides of this groove the endodermis is continuous, but towards the base it becomes broken up, and at the very bottom is wanting as a specially differentiated layer, so that the ground-tissue internal to ("medulla") and external to ("cortex") the sclerenchymatous zone is continuous.

The general structure of the central cylinder is the same as that in the more distal portion described above, but there are many more medullary sclerenchymatous strands, some of which are completely separated from the sclerenchymatous zone enclosing the medulla. In the centre of each medullary strand is a single vessel.

(8) CORYPHA AUSTRALIS, R. Br.

The limiting-layer consists of almost isodiametrical thin-walled lignified cells, most of which are exfoliated—exposing the underlying layers of thick-walled, elongated, pitted cells, which are only slightly lignified. Following this zone is one of some six or seven cells in depth, composed of parenchyma. Then comes a zone of elongated, square-ended cells, comparatively slightly lignified, and passing gradually into a large-celled parenchymatous inner cortex, with very irregular air-spaces and many scattered lignified parenchyma-cells with thick pitted walls. No fibres are present in the cortex. In the innermost zone the air-spaces are absent, but there is much lignified parenchyma.

The endodermal cells are about four times as long as broad. Some of these are thickened and lignified on all but the outer tangential walls; others are thin-walled and slightly cuticularized.

The pericycle, usually two cells in depth, is parenchymatous.

The ground-tissue of the central cylinder is composed chiefly of cellulose-walled parenchyma, but intermingled with it are many lignified sclerenchymatous elements.

The protoxylem-vessels are lignified, but the larger internal vessels retain their cellulose walls.

Occasionally a V is formed enclosing a phloem-group.

In the centre of the root is a thin-walled, parenchymatous pith, in which are air-spaces formed in the usual manner. In the centre of the pith runs a vessel surrounded by a sheath of prosenchymatous elements, some of which are lignified.

(9) CORYPHA UMBRACULIFERA, Linn.

Some of these roots show the contractile nature very clearly. The surface is transversely wrinkled and the whole root is very parenchymatous.

(a) *Large contractile Root.*—The limiting-layer is much disorganized and is followed by a parenchymatous cortex with extremely irregular air-spaces, the cells bounding which often show signs of extensive mucilaginization of their walls. No fibres or lignified cells are present. The endodermis is cuticularized and consists of square cells with no trace of lignification. The pericycle is ill-defined, but appears to consist of one layer of parenchyma with rather dense contents.

The whole of the ground-tissue of the central cylinder is parenchymatous, the xylem-plates and the phloem-groups being widely spaced in its periphery. There is no medulla, the whole central portion being occupied by polygonal strands of small thin-walled parenchyma, each enclosing a single lignified vessel. These strands are separated from one another by compressed and disorganized bands of cells. These strands correspond to the sclerenchymatous medullary strands which occur in so many palm-roots.

(b) *Non-contractile Roots.*—The cortex is composed of parenchyma, some of the cells of which contain starch-grains staining bright red with saffranin.

The grains show the leucoplasts very admirably, they are of the normal small conical form. Through the cortex run bundles of fibres, bounded by cells containing crystals of calcium oxalate. Very irregular air-spaces are present.

The endodermis is composed of cells about three times as long as broad, many of which are lignified, the rest being cuticularized. The pericycle is made up of two layers of lignified cells with large pits in their walls.

The ground-tissue of the cylinder is very greatly reduced.

The protoxylem- and phloem-groups occupy the periphery of the cylinder, while the whole interior is occupied by enormous vessels embedded in sclerenchymatous sheaths, partially separated from one another by the ground-parenchyma.

(10) LICUALA GRACILIS, Blume.

Limiting-layer of thin-walled lignified non-cuticularized cells.

The outer cortex is composed of small-celled slightly lignified parenchyma. In some roots the lignification proceeding both centripetally and centrifugally has not met, so leaving a narrow zone of non-lignified elements. This is best seen in young roots and appears to have undergone lignification in older roots. This is followed by a parenchymatous inner cortex with large radially extensive air-spaces and provided with elongated, square-ended, deeply pitted, lignified cells. There are no fibres. The innermost layers of the cortex are without air-spaces. The endodermic cells are much thickened and lignified in the "fibrous" manner.

The pericycle consists of two layers of lignified pitted cells. Internally to this comes a zone of sclerenchyma in which are embedded the protoxylem- and phloem-groups. This surrounds a central parenchymatous pith, which may be more or less lignified. In the smallest roots available for examination there were no fibrous strands in the medulla, but older portions showed all stages from a single fibrous bundle with its central vessel to sections in which nearly the whole pith is occupied by these strands, and instead of a single vessel, two to six may be present in each strand, generally one large vessel accompanied by from one to five smaller ones. In some cases two groups of vessels may be found in one fibrous strand.

(11) LICUALA SPINOSA, Thunb.

Similar in all essential respects to *L. gracilis*. The central pith is occupied by fibrous strands enclosing several vascular elements and in some cases two groups of vessels are present in each strand.

(12) LIVISTONA INERMIS, R. Br.

The limiting-layer is more or less lignified and consists of small regularly arranged cells. The outer cortex is made up of elongated lignified cells. The inner cortex is parenchymatous, with very irregular air-spaces and elongated, lignified, pitted cells.

The cells of the innermost portion of the cortex are tangentially compressed, and among these are many densely lignified and extremely thick-walled stone-cells, some of which are quite spherical. The endermic cells are lignified and much thickened, except on the outer tangential walls. The pericycle consists of one layer of lignified elements. A broad sclerenchymatous zone contains the xylem and phloem, and very definitely delimits the central pith, through which run fibrous elements, but no sclerenchymatous strands with vessels.

(13) LIVISTONA ROTUNDIFOLIA, Mart.

The cortex is parenchymatous with admixture of single lignified and pitted elements, but without fibrous strands. The air-spaces are irregular and comparatively small. The endodermis is of the usual lignified type. The pericycle is two cells in thickness, lignified and pitted. The sclerenchymatous zone is very densely lignified and thickened, giving to the central cylinder an extremely hard and solid character. No V's are formed, and there are no vessels which cannot be definitely allotted to their respective protoxylem-group.

There is a parenchymatous pith in which are present some lignified elements.

(14) LIVISTONA AUSTRALIS, Mart.

Externally occur three or four layers of oblong, strongly lignified, much thickened and pitted cells, the lumina of which are almost obliterated. Then follows a broad zone of prosenchymatous elements, generally lignified, and then the parenchymatous inner cortex with small irregular air-spaces and lignified elongated cells scattered singly or in small groups; no fibrous strands occur.

The endodermis and pericycle are as in *L. rotundifolia*. There is a sclerenchymatous zone in which the xylem and phloem are embedded. The xylem frequently shows

V-formation. In the centre is a parenchymatous pith, through which runs a single sclerenchymatous strand, enclosing a central vessel. This strand was followed for more than 12 cms. as a freely running strand without exhibiting any tendency to fusion with the sclerenchymatous zone. The central element in this strand was clearly shown to be a normal vessel, similar to the larger vessels occurring in the sclerenchymatous zone.

(15) LIVISTONA OLIVÆFORMIS, Mart.

The limiting-layer is almost entirely exfoliated and is succeeded by a few layers of square-ended, oblong cells, more or less lignified. These pass gradually into fibrous elements internally, which become lignified centrifugally. Then follows the parenchymatous cortex with comparatively small and very irregular air-spaces and some lignified elongated individual elements. The endodermis is like that in *Livistona rotundifolia*. The pericycle is two cells in thickness and encloses the sclerenchymatous zone in which the xylem and phloem lie. Irregular V's are formed, and the large vessels extend some distance internally. The central pith is not very clearly delimited from the sclerenchymatous zone; it consists of parenchyma with many irregular air-spaces.

(16) LIVISTONA CHINENSIS, Hort.

The limiting-layer is entirely exfoliated. The periphery is occupied by a zone four elements in thickness, much lignified and thickened, and is followed by thin-walled prosenchymatous cells which more internally exhibit lignification. The inner parenchymatous cortex has small air-spaces and some square-ended, pitted, lignified cells. The endodermis and pericycle resemble those of the other species of *Livistona* examined. The protoxylem-groups and the phloem occupy the periphery of the central cylinder and are embedded in a sclerenchymatous zone. The larger vessels extend some distance internally. In roots of small diameter the medulla is entirely parenchymatous, but in larger roots several sclerenchymatous strands in which are embedded one or two vessels traverse the medulla. Generally these strands are quite free from the sclerenchymatous zone, but occasionally one is seen in lateral continuity with it.

The central cylinder shows in the larger roots a slight lateral invagination, into which the endodermis extends.

This is the only irregularity in these roots.

(17) SABAL GLAUCESCENS, Lodd.

The limiting-layer is composed of isodiametric, thin-walled, lignified cells. Under this layer are several layers of lignified fibrous cells, a single layer in the middle being non-lignified. This zone passes gradually into a large-celled parenchymatous cortex with large irregular air-spaces. There are no fibrous elements and comparatively little thin-walled lignified parenchyma. In some cases the remains of the elements whose disorganization has given rise to the air-spaces are very well shown. The innermost layers of the cortex are more compact and without air-spaces. The endodermic cells are about six times as long as broad and of the usual lignified type. The pericycle is generally two-layered, but opposite the phloem it becomes three-layered. The cells are non-lignified, but the cellulose walls are thickened in a scalariform manner. The sclerenchyma in which the xylem and phloem lie extends to the centre of the root. The protoxylem- and the phloem-groups run in the periphery. More internally there is a single ring of large vessels. In some cases one of these forms the apex of a V, the arms of which are formed by two protoxylem-groups.

Towards the centre of the root are two bands of parenchyma separated by a broad sclerenchymatous mass enclosing two large vessels. This band represents the medullary sclerenchymatous strands of many other palm-roots.

In another root a definite parenchymatous pith without sclerenchymatous strands but with air-spaces and some lignified cells occurs.

(18) Sabal Adansoni, Guerns.

The limiting-layer is composed of thin-walled isodiametric cells with dark contents and slight lignification of the walls. Then follows a zone of parenchymatous elements, the outer members and a few of the innermost of which are lignified, lignification proceeding centripetally and centrifugally. The inner cortex is parenchymatous, the middle region being composed of longitudinal diaphragms of cells separating large radially arranged air-spaces. In this region also occur elongated, lignified, and pitted elements, but no fibres. The innermost zone consists of smaller cells and some lignified elements, but no air-spaces. The endodermis is similar to that in *S. glaucescens*. The pericycle is only one cell in thickness, except opposite the phloem, where it becomes two cells in thickness. It is lignified and pitted. The sclerenchymatous zone extends nearly to the centre of the root and carries peripherally the protoxylem and the phloem. There is a single ring of large internal vessels; occasionally this ring is doubled locally. Centrally a parenchymatous pith occurs, having in its midst a large air-space formed by disintegration of parenchymatous elements.

(19) Sabal Palmetto, Lodd.

The slightly lignified limiting-layer is succeeded by a prosenchymatous zone, of which the outermost elements alone are lignified. This zone passes gradually into a large-celled parenchymatous cortex with large radially extending air-spaces and without fibrous bundles or individual lignified elements. The innermost layers of the cortex are composed of smaller-celled parenchyma without air-spaces. This layer is incompletely separated from the main body of the cortex by an irregular zone of lignified pitted elements similar to those scattered irregularly throughout the cortex of many other species. The endodermic cells are thin-walled, non-lignified, and non-cuticularized. The pericycle is generally three cell-layers in thickness, except opposite the protoxylem, where only two layers may be present. The pericyclic cells have thin cellulose walls.

The xylem and phloem are embedded in non-lignified prosenchyma and parenchyma. The innermost prosenchyma of this zone alone is lignified. The outermost protoxylem-elements alone are lignified, the inner vessels being quite thin-walled and retaining their cellulose nature. There is a central non-lignified parenchymatous pith with irregular air-spaces formed by disintegration of cell-walls.

In other cases the xylem and phloem are embedded in lignified sclerenchyma, the vessels are all lignified, and there is a very small pith in the centre.

(20) SABAL FILAMENTOSA, H. Wendl.

The limiting-layer is of the usual type and is succeeded by a zone of elongated lignified elements, generally square-ended. These are followed by the parenchymatous inner cortex with air-spaces in three or four irregular circles and separated from one another by diaphragms only one cell in thickness. In this region occur lignified cells which may be isodiametric or elongated. No fibres are present. The cells of the endodermis are so strongly thickened and lignified on all but the external tangential walls that the lumina are almost occluded.

The pericycle varies from one to two cells in thickness; it is generally lignified, but some of the cells retain their cellulose nature, the cellulose regions generally occurring opposite to a phloem-group.

The central cylinder is almost entirely occupied by sclerenchymatous tissue in which lie the xylem and phloem. The phloem-groups extend centrally to a somewhat greater extent than usual. There is a double ring of large internal vessels without apparent relation to the protoxylem-groups. Centrally there is a very small parenchymatous pith consisting in transverse section of four or five elements only.

II. BORASSINÆ.

(21) HYPHÆNE THEBAICA, Mart.

The limiting-layer is exfoliated. Peripherally there is a dense zone of lignified elements. This is followed by the parenchymatous inner cortex with small irregular air-spaces and individual lignified parenchymatous elements and bundles of very thick-walled and pitted fibres. The endodermic cells are thin-walled, non-lignified, and non-cuticularized. The partially lignified pericycle is one or two cells in thickness. There is a ground-mass of sclerenchyma in which lie the xylem and phloem. A single ring of large vessels lies internally to the protoxylem-groups, and these form the apices of irregular V's. Two adjacent phloem-groups also frequently converge centrally and may form a phloem V, the arms of which enclose a small xylem-group. In other cases an isolated phloem-group occupies the apex of the phloem V, and the arms instead of being continuous with this are separated from it by portions of the sclerenchymatous tissue. In the centre of the root is a parenchymatous pith, largely occupied by sclerenchymatous strands each enclosing a vessel; usually the vessel is placed quite laterally in the strand instead of in the centre as in most roots. Some of the strands are connected laterally with the sclerenchyma-zone.

(22) Latania Loddigesii, Mart.

The limiting-layer is exfoliated and a zone of elongated more or less lignified elements occupies the periphery ; a parenchymatous cortex follows, in which occur comparatively small and irregular air-spaces and a few lignified and pitted elements. The innermost cortical zone consists of much more regularly arranged cells, without air-spaces, but with a considerable proportion of fibrous elements with thick lignified walls scattered irregularly and not grouped into bundles.

The endodermic cells are thin-walled, non-cuticularized, and non-lignified.

The pericycle is one cell in thickness opposite the xylem- and phloem-groups, two cells in thickness between these groups.

The xylem and phloem are embedded in non-lignified prosenchyma, the inner portion of this zone alone being lignified, the process commencing internally and proceeding centrifugally.

The large vessels of the interior are arranged roughly in one ring, but deep bays of prosenchyma projecting into the pith also enclose vessels occasionally. Small-celled groups occur amongst the large internal xylem-vessels. These appear to be of the nature of phloem, but differentiation has not gone far enough to state with certainty.

A parenchymatous pith occupies the centre of the root in which runs a single prosenchymatous strand, the outer elements of which are lignified, lignification proceeding centripetally.

This strand encloses a single large vessel.

(23) Latania Commersoni, Mart.

The outer cortex forms a narrow zone. The inner parenchymatous cortex possesses small irregular air-spaces and bundles of well-developed strongly lignified fibres with stegmata. The endodermis is thin-walled and non-lignified. The pericycle is one-layered.

There is a broad zone of sclerenchyma enclosing centrally a very irregular pith. The xylem and phloem lie in the sclerenchymatous zone.

The protoxylem-groups, as usual, are arranged peripherally, while the large internal vessels are scattered throughout the sclerenchyma, without relation to the protoxylem-groups. The phloem-groups alternating with the protoxylem-groups are practically undeveloped, but scattered patches of phloem lie amongst the large internal vessels of the xylem, being distributed centrally nearly as far as are these vessels.

III. LEPIDOCARYINÆ.

(24) Raphia Ruffia, Mart.

The limiting-layer cells are somewhat elongated ; these together with the three or four underlying layers, which are composed of cells of similar form, are slightly cuticularized. They are succeeded by a zone of lignified elongated cells, more or less square-ended. The parenchymatous inner cortex has large and irregular air-spaces, often separated from one another by only a single layer of cells. Through this portion of the cortex run lignified fibres, usually singly, sometimes in pairs, but never in bundles. The innermost zone of the cortex is composed of smaller, more tightly packed cells, without fibres or air-spaces.

The endodermic cells are lignified and thickened almost equally on all the walls. The cells are about four times as long as broad. The pericycle varies from one to two cells in thickness; the cells are about three times as long as broad, somewhat lignified and pitted. Inside the pericycle comes a broad zone of sclerenchyma enclosing a central parenchymatous pith. In this zone the xylem and phloem are embedded.

The majority of the xylem-groups consist of a few protoxylem-vessels followed internally by a single large vessel, but sometimes the large vessel is wanting, or represented by only a comparatively small structure.

(25) RAPHIA HOOKERI, C. Mann & H. Wendl.

The limiting-layer consists of thin-walled isodiametric cells which are cuticularized and slightly lignified. This is followed by about six layers of slightly lignified small fibrous cells, succeeding which internally is the parenchymatous inner cortex, the external layers of which are composed of small tightly packed cells. The middle layers consist of larger cells with large air-spaces arranged in many series, and bundles of fibres provided with well-developed stegmata. Immediately outside the endodermis are two or three layers of cells without air-spaces, but with bundles of fibres, which here approach much more closely to the central cylinder than is usually the case.

The endodermic cells are elongated and fibrously thickened and lignified as usual, and the lumina are largely occluded.

The pericycle is one or two cells in thickness, consisting of cells about twice as long as broad, slightly lignified and minutely pitted. The ground-tissue of the central cylinder is sclerenchymatous, and generally extends to the centre, no pith being developed. In other cases there is a lignified central tissue distinct from the sclerenchymatous zone, and containing a few non-lignified elements. It is seen as a distinct tissue when the section is treated with sulphuric acid.

The protoxylem-vessels are succeeded internally by a series of vessels gradually increasing in size, the innermost nearly reaching the centre of the root. The peripheral xylem-groups form **V**'s and enclose the phloem-groups. Occasionally a xylem **V** encloses a phloem **V**, and this, again, a small xylem-group.

(26) METROXYLON SAGU, Roxb.

The limiting-layer is exceptionally well preserved and consists of thin-walled isodiametric lignified elements. This is succeeded by a zone of more or less square-ended, elongated, lignified, pitted cells, and this again by the parenchymatous inner cortex with an irregular development of air-spaces, and strands of fibres bounded by stegmata. The cells of the endodermis are very greatly thickened and the lumina almost occluded. The lignified pericycle is two elements in thickness; the inner cells are, however, much reduced opposite the protoxylem. The whole of the ground-tissue of the central cylinder is sclerenchymatous, no pith being present. Two rings of large vessels succeed the protoxylem-groups internally, and V's are formed. Not infrequently the phloem-groups also form V's, and thus we find a xylem V enclosing a phloem V and this again enclosing a small xylem-group.

(27) METROXYLON RUMPHII, Mart.

This root resembles that of *M. Sagu* in all respects, except that no complete phloem V's were found. One incomplete phloem V occurred, one limb being separated from the rest of the structure by a portion of sclerenchyma, the apical group being continuous with the other limb.

(28) PLECTOCOMIA ELONGATA, Blume et Mart.

The limiting-layer is exfoliated, the periphery being occupied by fibrous lignified elements. More internally these elements become extremely densely lignified and sclerozed, the lumina being almost occluded. The inner cortex is mainly parenchymatous with small air-spaces, and through this portion run strands of long narrow fibres surrounded by stegmata. Of the parenchymatous elements many individual cells are lignified and deeply pitted. These may occur in long strings, cell after cell being lignified in the same manner, and some of the elements are usually much elongated. In some cases large elongated elements are also present with very thick walls, and containing mucilage and raphides. The endodermis is thin-walled and only slightly lignified. The pericycle is also thin-walled. The sclerenchymatous zone is composed of elements extremely densely lignified, thickened and sclerozed, very dark-coloured, and with their lumina nearly occluded.

The vascular elements are normal in structure and arrangement. There is a central parenchymatous pith, in which are a few lignified elements.

IV. CEROXYLINÆ.

(29) CARYOTA OCHLANDRA, Hance.

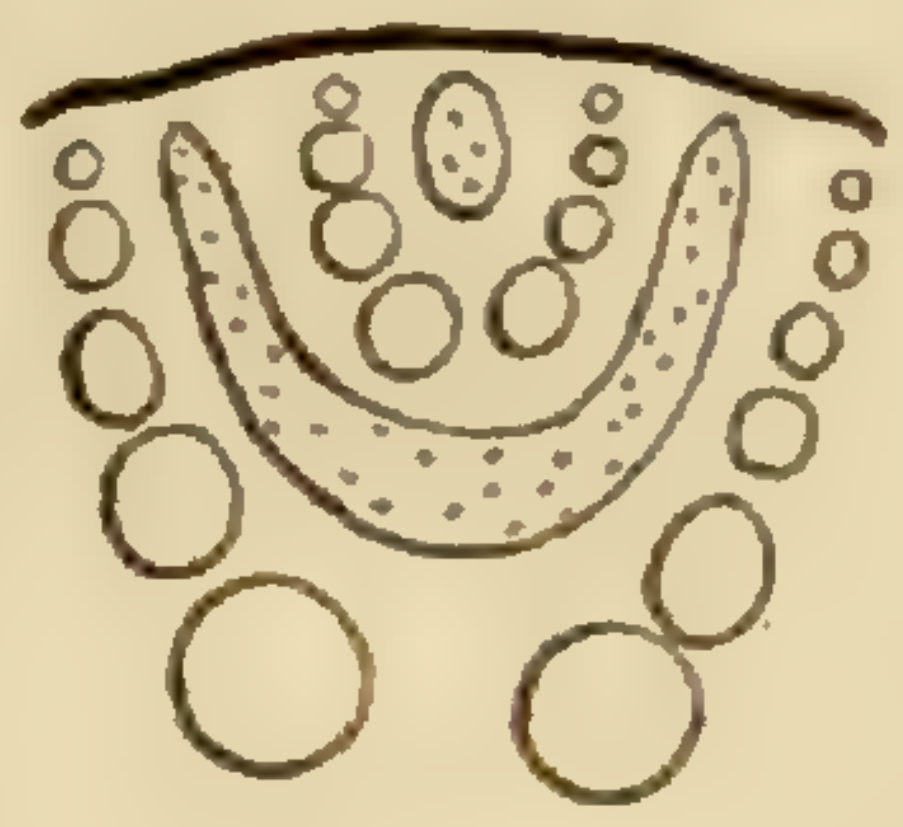
The limiting-layer is well marked and of the usual type. It is succeeded by a narrow zone of small elongated lignified elements with reduced lumina.

These are followed by the parenchymatous inner cortex, the outer layers of which are dense, while the broad inner zone is provided with large air-spaces very irregularly developed. Amongst these are scattered bundles of fibres. The endodermis is of the usual lignified type; the pericycle is two cells in thickness; the sclerenchymatous zone extends to the centre of the root (*i. e.*, there is no pith), and in this are arranged peripherally the protoxylem- and phloem-groups. The large internal vessels are exceptionally well developed and extend to the centre of the root, the structure recalling that of the non-contractile root of *Corypha umbraculifera*, Linn., but here on a much smaller scale V-formation occurs with the outer members of these internal vessels.

(30) CARYOTA RUMPHIANA, Mart.

The cortical tissues are generally similar to those in *C. ochlandra*, but not so much broken down by air-space formation. The lignified tissue of the outer cortex is more strongly developed. The bundles of fibres of the inner cortex are present as in the last species, and in addition to these is a zone of stone-cells just external to the endodermis. There is a very dense sclerenchymatous zone in the central cylinder, but here there is usually a small irregular pith in the centre, which may contain an air-space and some mucilaginous elements. The phloem-bundles are considerably prolonged centrally, and the large internal vessels of the xylem are developed to within a short distance of the central pith. Xylem and phloem **V**'s are very frequent, and we may even get a phloem-group embraced by a xylem **V**, this again by a phloem **V**, the whole complex being embraced by a xylem **V** just incomplete at the apex, as shown in the accompanying diagram (text-fig. 10).

Fig. 10.



(31) CARYOTA URENS, Linn.

The cortex is here much less richly supplied with air-spaces than in the last two species. The fibrous bundles are well developed, as are also the stone-cells surrounding the endodermis. These elements have extremely thick walls, almost occluding the lumina. The endodermis is of the usual lignified type and the pericycle is one-layered. The sclerenchymatous zone is broad and encloses a central pith. The phloem-groups do not extend nearly so far centrally as in *C. Rumphiana*, Mart., and the large internal vessels are much more peripherally placed, and they can with greater certainty be relegated to their own one or two protoxylem-groups. In the central pith run three strands of sclerenchyma, each with its central vessel. One of these strands is laterally connected with the sclerenchymatous zone.

In a smaller root the structure is much the same, but only one medullary sclerenchyma-strand is present.

(32) CARYOTA sp. (Queensland).

The limiting and underlying layers are normal, but the latter contain large mucilage-cells with thick walls. The inner cortex has small and very irregular air-spaces. It has some thick-walled parenchyma and a few stone-cells. There are relatively few fibrous bundles in the cortex. The most striking feature of the inner cortex in this species is the extraordinarily rich development of mucilage-reservoirs, generally formed by the lengthening and thickening of the walls of a single cell. These cells may form rows, and are full of dense dark-coloured mucilage, in which lie raphides. The endodermis is typical and the pericycle is one-layered. Inside this is a comparatively narrow sclerenchymatous zone enclosing a parenchymatous pith. The xylem- and phloem-groups lie peripherally in this zone, and there is only one irregular ring of large internal vessels. V-formation occurs, as there are fewer of the large vessels than there are protoxylem-groups. In the central pith run three sclerenchymatous strands each enclosing a large vessel.

(33) ARENGA WIGHTII, Griff.

The limiting-layer is persistent, and consists of thin-walled slightly lignified isodiametric cells and is succeeded by a zone of small, square-ended, elongated, lignified, thick-walled elements. The inner cortex is parenchymatous with very irregular air-spaces and strands of fibres bounded by stegmata. In addition to the fibres, individual thick-walled, pitted, lignified, parenchymatous cells occur, particularly well developed immediately around the endodermis, in which region air-spaces and fibrous bundles are wanting. The endodermis is thick-walled and lignified; the pericycle is two or three cells in thickness, and the elements are short and isodiametric. The xylem and phloem are embedded in a sclerenchymatous zone in which the vascular elements do not extend far centripetally. There is one ring of larger internal vessels, and centrally there is a parenchymatous pith with some lignified elements.

(34) IRIARTIA sp.

The limiting-layer cells are slightly lignified and project as papillæ on the surface. A layer of thickened lignified elements with narrow lumina succeeds the limiting-layer, and is followed by a zone of prosenchyma, of which the outer layers are lignified. The parenchymatous inner cortex is traversed by bundles of fibrous elements, only the outer members of which are lignified. In the centre of each bundle runs a long element with transverse walls very like those of the sieve-tubes, but no definite pitting could be made out. Of these De Bary says, "perhaps sieve-tubes." Unfortunately older roots could not be obtained, and it was found impossible to settle the question from the available material. In the most internal part of the cortex run definite rounded air-spaces, and in this region also occur individual lightly lignified parenchymatous elements. In a root $\frac{1}{4}$ inch in diameter a complete endodermis of lignified cells exists. At one point it was doubled, two cells occurring on the same radius. The central cylinder in this root is elliptical in outline. The pericycle is two cells in thickness, except just opposite the protoxylem-groups, where it is reduced to one cell in thickness. The xylem and phloem are embedded in a prosenchymatous zone, only the periphery of which is lignified. The protoxylem-elements, which are only very slightly lignified, are embedded in patches of non-lignified tissue. V-formation is rare, but there is a tendency to xylem V's at the ends of the ellipse. Only one ring of internal vessels exists; these are non-lignified, but are embedded in lignified sheaths. Centrally there is a parenchymatous pith with very irregular air-spaces.

In the transverse section of a larger root the endodermis, instead of forming a complete ring, forms a series of arcs of small radius as compared with the radius of the whole central cylinder. This gives a lobed outline to the cylinder, and in the depressions between the lobes the endodermis cannot be recognized as a definite layer, the ground-parenchyma of pith and cylinder being in all respects similar and quite continuous. Immediately internal to such a gap is often a large vessel, sometimes accompanied laterally by one or two phloem-groups, sunk in the ground-tissue of the cylinder. At other points two phloem-groups may be in close proximity at such a gap, no xylem-group intervening. The arrangement of the arcs conveys the impression, borne out by examination of the apices, that they have arisen as independent procambial strands in the meristem.

In the large parenchymatous pith are developing strands of fibres, each with a central element, of the same nature as those described as occurring in the cortical strands.

In some cases the aerial roots bear lateral rootlets, which are reduced to spines. The structure of these spines is as follows:—

The periphery is occupied by a more or less disorganized layer of thin-walled cells, beneath which is a zone of parenchyma, followed by three or four layers of lignified elements with pitted walls and square ends, and succeeded by about three layers of cells of a similar character, but non-lignified. The parenchymatous inner cortex then follows; many of the outer cells show clear evidence of secondary division, as do also some of the other cells irregularly scattered throughout this region. The endodermis is in the form of two arcs, incurved at either end, where they are not continuous with one another, but may project inwards as plates of cells for some distance. The endodermic cells are lignified and somewhat thickened. The central cylinder consists of parenchymatous ground-tissue in which are embedded some lignified elements. The phloem-groups consist of three to five elements and are arranged peripherally as usual. The xylem is very greatly reduced, but the protoxylem may be seen to be exarch and to consist of annular elements, those developed more internally being scalariform. The whole ground-plan is that of a root, but greatly reduced as to its xylem-constituents.

(35) HYOPHORBE AMARICAULIS, Mart.

The limiting-layer is thin-walled and lignified, and is followed by a zone of more or less elongated and pitted cells, succeeded in turn by the parenchymatous inner cortex, through which are scattered individual lignified fibres, not collected into bundles. Comparatively small and very irregular air-spaces are present. In the zone immediately surrounding the endodermis occurs a complete circle—two or three elements in thickness—of very strongly lignified stone-cells with deep simple pits. The endodermic cells are comparatively thin-walled and slightly lignified on all except the outer tangential walls. The two-layered pericycle is also thin-walled. The central cylinder is laterally depressed on one side, and here the endodermis dips in, but is quite continuous. The protoxylem-elements are embedded in non-lignified parenchyma, but the ground-mass of the cylinder is sclerenchymatous, forming a ring enclosing a central pith into which bays of the sclerenchyma project. The pith is parenchymatous, with a few elongated, generally square-ended elements. Through this pith run sclerenchyma-strands, most of which surround a central non-lignified vessel. Some of these strands unite externally with inwardly projecting bays of sclerenchyma of the ring. In larger roots the central cylinder is much lobed, and into each depression the endodermis dips, and at the bottom of the larger depression it is discontinuous as a specially differentiated layer, the cortical and medullary parenchyma being quite continuous. At these points the sclerenchymatous ring is incomplete, and the adjacent ends are inflected, carrying inwards with them the last two or three xylem- and phloem-groups. The pith is parenchymatous, and there are many sclerenchymatous strands with central vessels.

(36) GEONOMA SEEMANNI, H. Wendl.

The limiting-layer is of the usual type, and is followed internally by a zone of elongated elements densely lignified in the external layers, but becoming less and less densely lignified centripetally, the innermost layer of the zone being entirely non-lignified. Passing further in a central direction lignification gradually increases, but not to the same extent as in the outer layers just mentioned. The parenchymatous inner cortex contains air-spaces and bundles of fibres. Immediately around the endodermis are several isolated lignified elements, somewhat elongated, thick-walled, and pitted. The endodermis is of the usual lignified type. The pericycle is two cells in thickness. In a sclerenchymatous zone lie the xylem and phloem. Only one ring of large internal vessels is present. In other roots the outer portion of the ground-tissue of the central cylinder is non-lignified, and the phloem- and protoxylem-groups are embedded in parenchyma.

(37) GEONOMA PUMILA, H. Wendl.

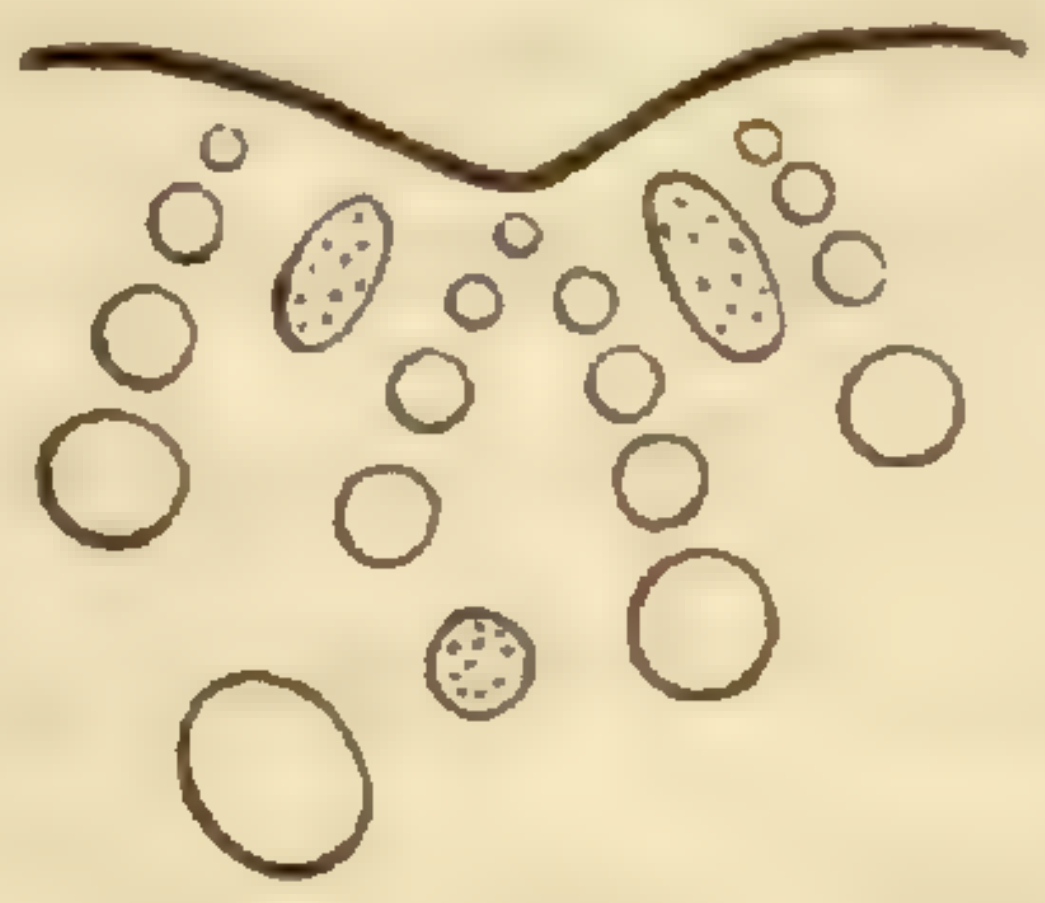
The limiting-layer is almost entirely exfoliated, the periphery being then occupied by an external cortex of the usual type of elongated cells, passing gradually into the parenchymatous inner cortex, which is provided with comparatively large and irregular air-spaces. In this region lie long, square-ended, lignified elements. The endodermis is of the usual lignified type. The pericycle is two layers in thickness; its elements are parenchymatous, much compressed opposite the protoxylem, but expanding opposite the phloem. The zone in which the phloem and protoxylem are embedded is parenchymatous and non-lignified, but internally there is a zone of lignified elements in which lies one ring of large internal vessels. There is centrally a loose parenchymatous cortex with irregular air-spaces.

(38) CHRYSALIDOCARPUS LUTESCENS, H. Wendl.

The limiting and tegumentary layers are developed as usual, and are followed by the outer dense zone of the parenchymatous inner cortex, in which are many elements containing dark-coloured mucilage. The inner zone shows small well-developed air-spaces arranged roughly in three circles. In this region are also bundles of fibres very richly developed, especially in the innermost layers. The endodermis is lignified and the pericycle is one-layered. The sclerenchymatous zone encloses a large central pith. In the sclerenchyma lie the xylem and phloem. There is only one ring of internal vessels, and these can usually be allotted to their particular protoxylem-groups, but occasionally V-formation obtains. The pith contains many small definite air-spaces.

In a section of a large root taken some distance from the stem-base, the central cylinder exhibits a depression on one side, and into this the endodermis dips. In this region the sclerenchymatous zone shows wedge-formation and xylem **V**'s occur. More proximally a complete gap in the sclerenchyma is found, and the endodermis dips in and becomes discontinuous. In addition to this several depressions occur in the cylinder, into which the endodermis sinks, but is quite continuous. At such a depression the arrangement of bundles is rather peculiar, the insinking of a phloem-group and convergence of two protoxylem-groups by their external ends being very well marked. (fig. 11.)

Fig. 11.



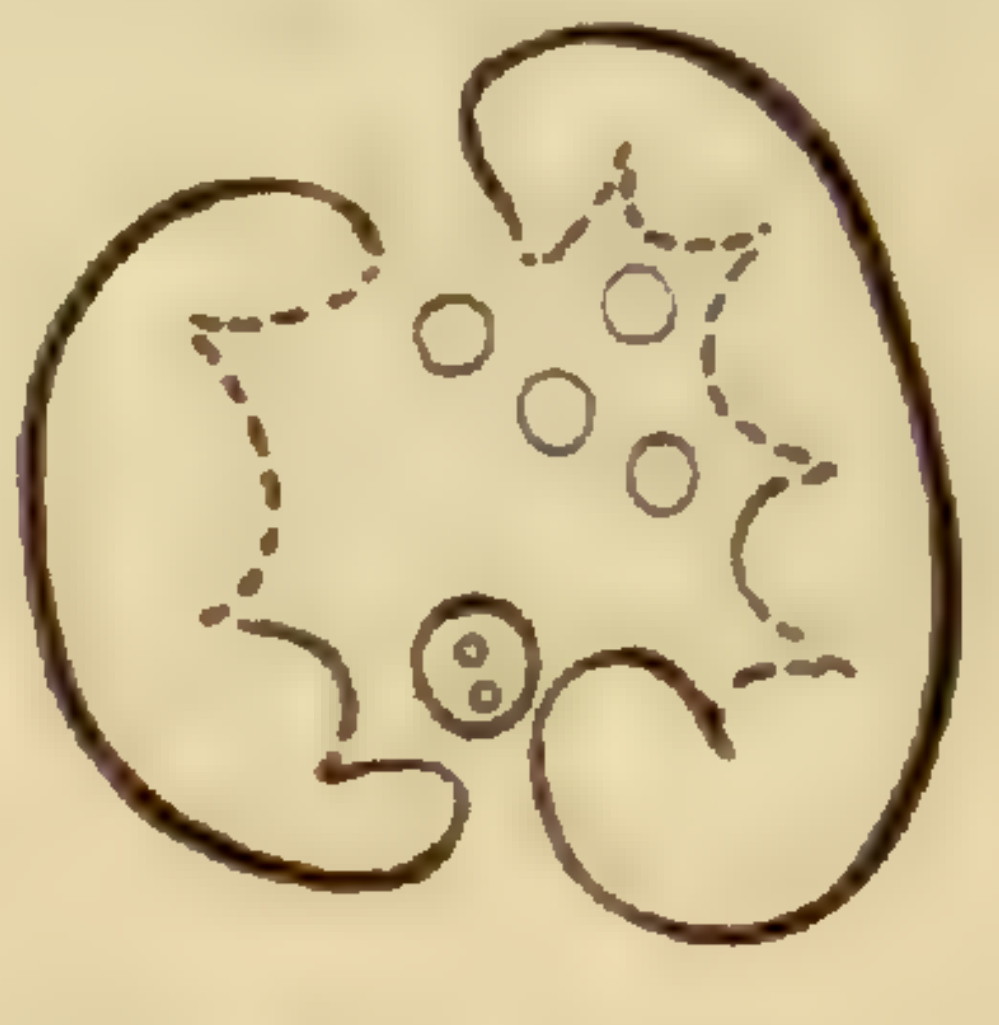
In the pith of such a root several free sclerenchymatous strands occur, each with one to three central vessels.

(39) DYPSIS MADAGASCARENSIS, Hort.

The outer walls of the limiting-layer cells are often much thickened, all the other walls remaining of the usual thin type. Following this is a zone of small elements filled with dark brown contents. Internally this zone gives way to the inner parenchymatous cortex, through which run bundles of fibres. The internal layers are provided with many-ranked small air-spaces. The endodermis is lignified and much thickened in the usual manner. The pericycle consists of one or two layers of cells. The xylem and phloem are embedded in a more or less lignified fibrous zone. **V**'s are of frequent occurrence in the xylem, the elements of which are confined to the periphery of the cylinder. In the centre is a large parenchymatous pith with very irregular air-spaces. One sclerenchymatous strand enclosing a single vessel runs laterally in the pith.

In larger roots the histological structure is similar, but the sclerenchymatous zone, instead of forming a complete circle, is composed of two entirely separate lobes, the free ends of which are inflected. Into the space between the two lobes the endodermis of each lobe dips and is lost in the general ground-tissue of the root. In these gaps are found bundles of fibres exactly like those of the cortex; these may penetrate the internal ground-tissue of the cylinder for a short distance. In the medulla are free sclerenchymatous strands with central vessels. One of these occurs just opposite one of the gaps in the cylinder, and externally to the central vessel in this strand runs a phloem-group. (Text-fig. 12.)

Fig. 12.

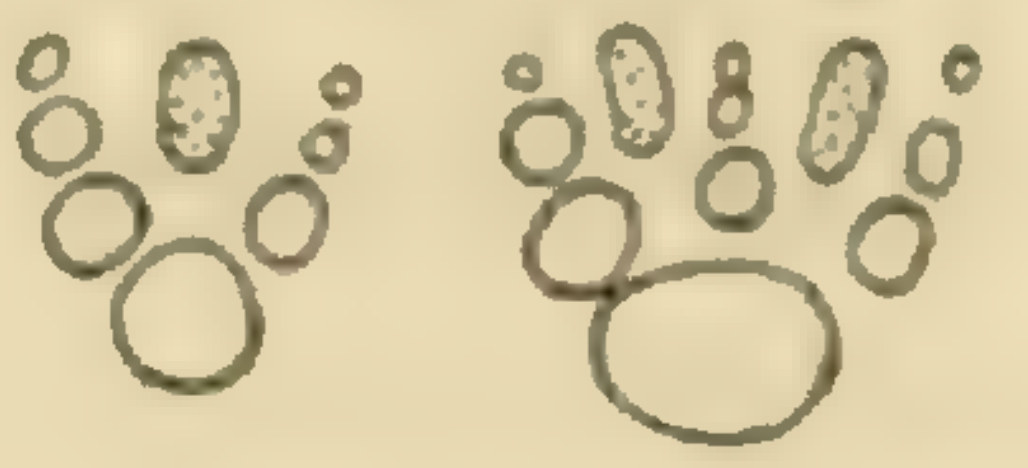


In still older portions the cylinder is split up into many separate arcs, the larger ones containing as many as forty xylem-groups. The ends of the arc are inflected as in the section just described. The smaller arcs may contain only one xylem-group, flanked on either side by a phloem-group. Both large and small arcs are externally bounded by an endodermis which dips into the gaps between the arcs and is lost in the common ground-tissue.

(40) OREODOXA REGIA, H. B. & K.

There is a thin-walled limiting-layer, followed by elongated lignified pitted elements. The cortex is largely parenchymatous, but widespread lignification obtains, and a special ring of lignified elements, two or three cells in thickness, surrounds the endodermis. The air-spaces are small and extremely irregular. The endodermis is of the ordinary lignified type; xylem **V**'s are frequent and also more complicated arrangements, as shown in the accompanying woodcut (text-fig. 13). There is generally only one ring of large internal vessels, which are peripherally placed. The xylem and phloem are embedded in a fibrous zone of very densely packed, thick-walled, and lignified elements. There is centrally a pith, through which run one or more sclerenchymatous strands with central vessels.

Fig. 13.

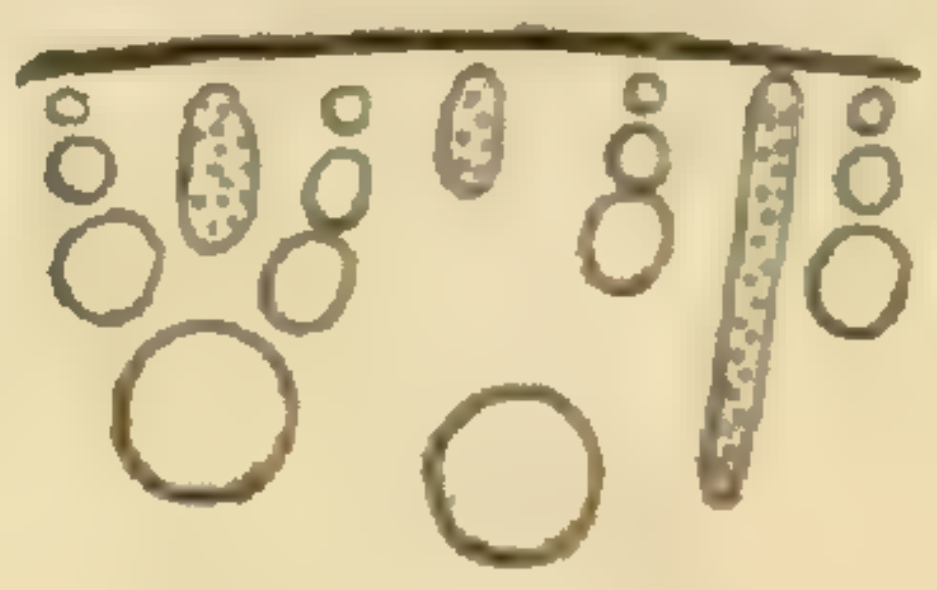


(41) HOWEA FORSTERIANA, Becc.

A. *Specimen from Glasgow.*—Limiting-layer and tegumentary layer normal, the latter containing much mucilage. The inner parenchymatous cortex contains irregularly arranged fibres, not usually united into bundles. In the internal portion of the cortex rather large air-spaces occur, together with bundles of fibres. The endodermis is lignified and the pericycle is generally one- (locally two-) layered. The sclerenchymatous zone contains the xylem and phloem as usual. The large vessels of the interior are so arranged that each protoxylem-group has its own large vessel (occasionally a **V** is formed). This leads to close packing of the large vessels, which are consequently radially compressed into an elliptical shape. The phloem extends centrally to a greater extent than in the majority of roots. In the centre there is a large parenchymatous pith.

B. *Specimen from Ceylon.*—The cortical air-spaces are here much smaller and the fibres more generally occur in bundles. The vascular elements are all peripherally placed in the sclerenchymatous zone. Where no large internal vessel abuts on the space between two xylem-groups, the intervening phloem-group may extend for a considerable distance centrally. (Text-fig. 14.) This is the only root in which this character has been seen so well developed. The large pith contains small air-spaces, and in a large root one or more free sclerenchymatous strands may occur, each with its central vessel. In large roots

Fig. 14.

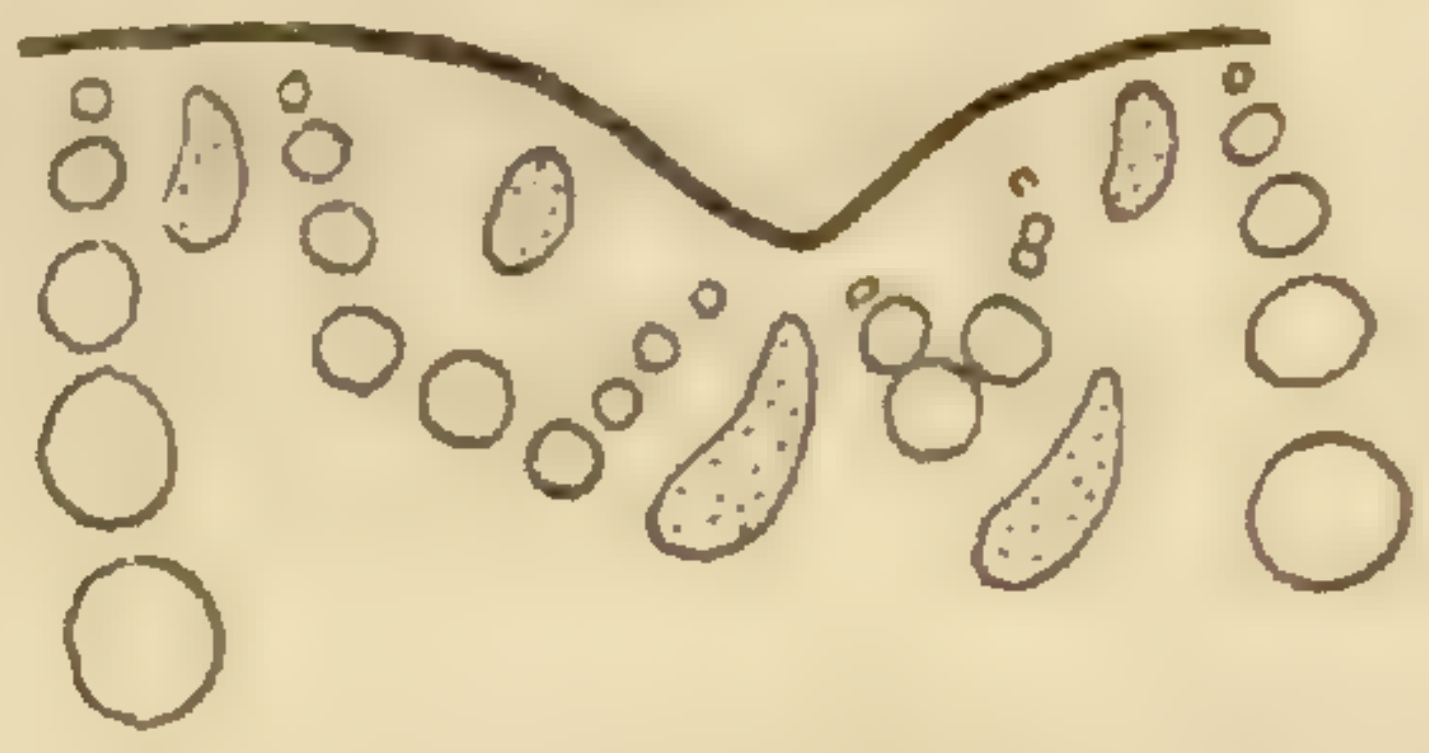


the sclerenchymatous zone is interrupted on one side, and into this gap the endodermis dips, being continuous round the inrolled margins of the sides of the gap, but lost internally, the cortical and medullary ground-tissue being quite continuous.

(42) HETEROSPATHE ELATA, Scheff.

The limiting and subjacent layers are of the usual type. The parenchymatous cortex has large air-spaces, and in the external layers of the inner cortex are lignified elements of two kinds—rows of lignified parenchyma and true fibres. In the internal layers the fibres occur in bundles. The endodermis is typically lignified. The non-lignified pericycle is one-layered. The xylem and phloem are embedded in a fibrous zone. The large vessels extend for a greater distance internally than usual, as do also the phloem-groups. Xylem and phloem **V**'s of a type similar to those in *Caryota Rumphiana*, Mart., are formed. In somewhat larger roots the central cylinder is lobed. Opposite the depressions the arrangement of xylem- and phloem-groups is peculiar (see text-fig. 15).

Fig. 15.



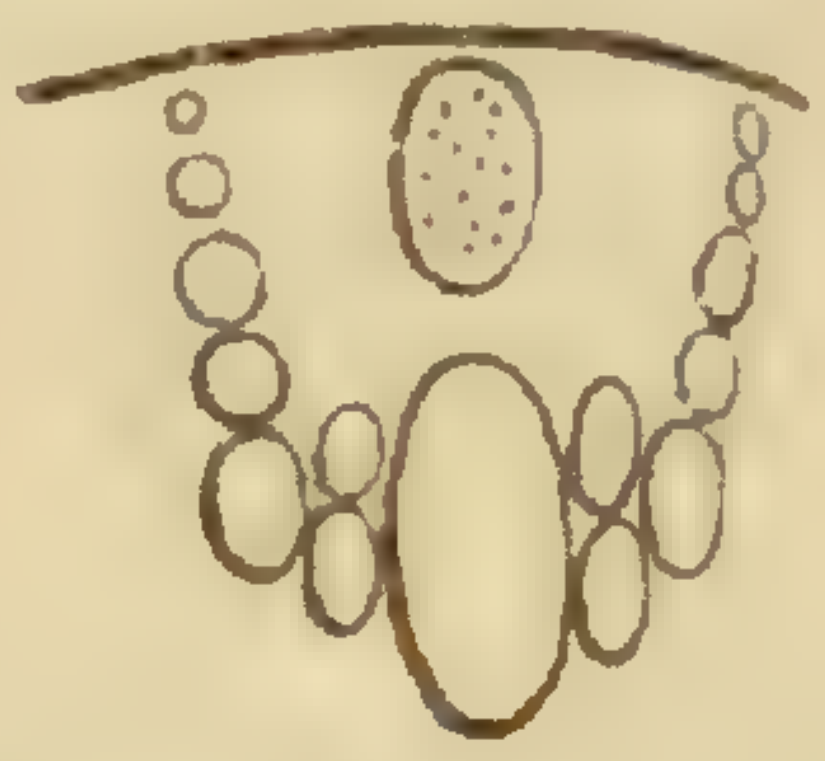
There are no completely free medullary strands, but many strands attached laterally to the fibrous zone project into the medulla, each strand having its central vessel. Some fibres occur in the pith, with tendency to arrangement into bundles.

In still larger roots the cylinder is completely broken up into lobes. The endodermis dips into the spaces between the lobes and there loses its identity. Bundles of fibres are well developed in the medullary parenchyma of these roots.

(43) ONCOSPERMA FASCICULATUM, Thw.

The parenchymatous cortex has small, very irregular air-spaces arranged in many zones, and bundles of fibres of the larger less densely lignified type, not arranged into definite strands bounded by stegmata such as we find in many roots, but agreeing closely with those found in *Kentia* sp. (*q. v.*). The endodermis is lignified; the pericycle one-layered. The xylem and phloem lie in a rather broad fibrous zone; **V**-formation occurs occasionally, but is not general. Many of the protoxylem-groups are without internal large vessels. In one **V** the xylem-groups instead of converging to the outer portion of the large vessel, as is usually the case, converge to the sides. (Text-fig. 16.)

Fig. 16.



The central medulla contains some irregular air-spaces.

(44) Euterpe sp.

The limiting-layer is slightly lignified. It is succeeded by a narrow zone of small elongated lignified elements. Through the parenchymatous inner cortex run lignified fibres with transverse walls, and also other lignified elements arranged in strands, whose fibrous nature is not nearly so evident. The air-spaces are large and irregular. The innermost cortical zone is much denser than the rest and is without air-spaces. The endodermis is lignified, and the pericycle one or two cells in thickness. The fibrous zone is of comparatively small width, and contains the xylem- and phloem-groups. Xylem V's are of frequent occurrence. There is only one ring of large internal vessels, and these are very peripherally placed. The pith is large and parenchymatous and contains regular air-spaces.

(45) Kentia sp.

The peripheral layer is composed of large isodiametric thin-walled lignified cells. These are followed by elongated lignified small elements, the outer of which are provided with dark contents. These pass internally into more densely lignified fibrous elements and these again are followed by the parenchymatous cortex with its large irregular air-spaces and bundles of fibres. These fibrous bundles, though fairly definite, are not by any means so well formed as those in *Raphia Hookeri* for example, and in other roots provided with stegmata. The fibres themselves are much broader, relatively thinner-walled, and with more considerable lumina, closely resembling those found in *Areca concinna*. The endodermis is much lignified and thickened on all but the outer tangential walls. The pericycle is generally two elements in thickness, but opposite to the protoxylem-groups it may be reduced to one. The xylem and phloem are embedded in a lignified zone of fibrous elements. Xylem V's are of frequent occurrence. There is only one irregular ring of large internal vessels. Centrally there is a parenchymatous pith in which lie some pitted fibres.

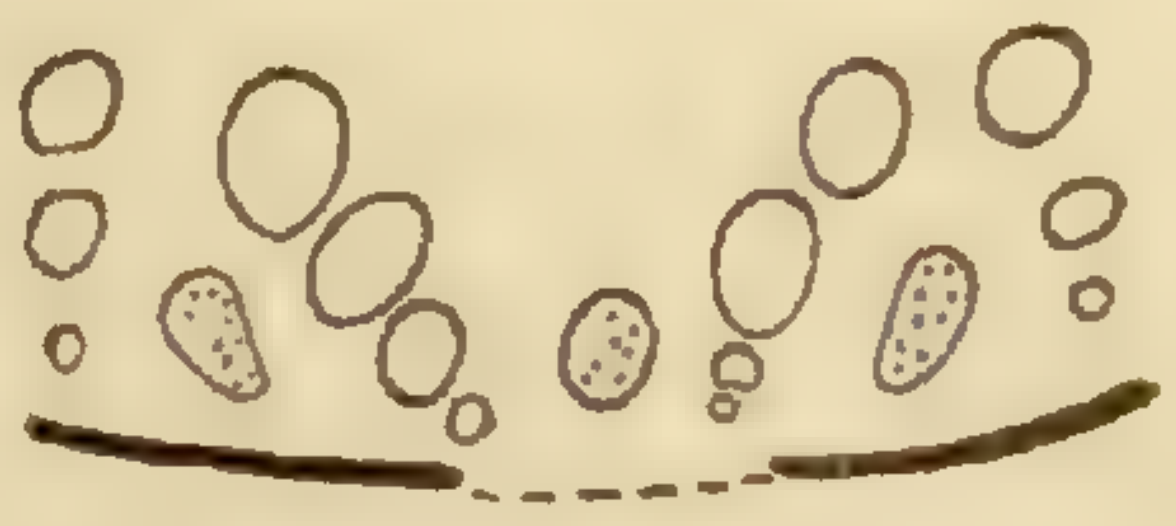
In large roots, passing from distal sections to proximal ones, the following stages are observed:—

(*a*) Outer cortex parenchymatous, with no air-spaces, but with sparsely scattered fibrous elements. Inner cortex of larger parenchymatous cells, among which run fibrous bundles and large air-spaces. The central cylinder presents a slightly lobed outline, the endodermis dipping into the lobes, but being quite continuous. The cylinder is incomplete on one side, and here the endodermis follows the incurved edges of the fibrous zone, and is lost internally in the parenchymatous ground-tissue. These free edges of the fibrous zone are very much inrolled, carrying in with them at least two phloem-groups. The gap between them is broad, and through it the ground-tissues of cortex and medulla are continuous. In both are embedded exactly similar fibrous bundles, except that those of the pith tend to be slightly less strongly lignified.

(*b*) In a section taken more proximally the cylinder is still more lobed, and several gaps, bounded by the inrolled edges of the fibrous zone, are present. Into these gaps the endodermis dips and is lost. Some of the arcs of fibrous tissue are so greatly inrolled that a complete ring of tissue is formed in which the xylem- and phloem-groups are only wanting for a short space internally. Round these the endodermis is nearly continuous. Through each gap the parenchymatous tissue of cortex and medulla is continuous, and fibrous bundles are very abundantly developed in the medullary portion.

(*c*) In sections from a still more proximal portion of the same root the vascular cylinder consists of a greater number of separate arcs, many of which form nearly complete cylinders. The xylem-groups of the internal portion of these cylinders are approximated by their protoxylem-elements, the metaxylem portions divaricating widely. A phloem-group occupies the innermost point of such a cylinder (text-fig. 17). Such a complete ring of fibrous tissue encloses a portion of the general parenchymatous ground-tissue, continuous below with the medulla, when the ring becomes incomplete internally. In this central parenchyma occur two or more strands of fibres similar to those of the pith and cortex.

Fig. 17.



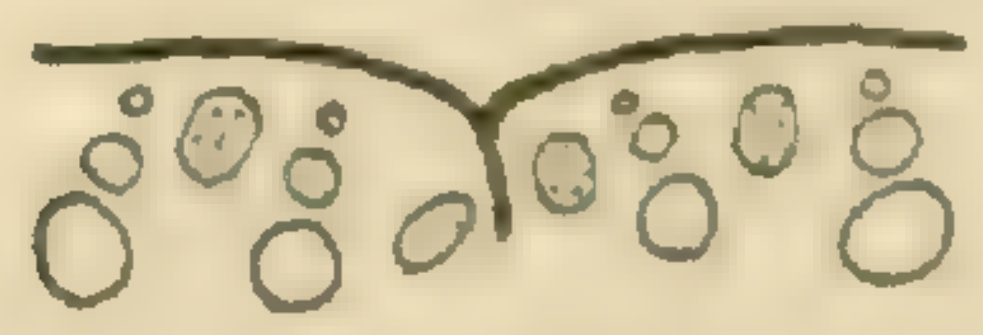
The endodermis is in this region strongly lignified on all but the external tangential walls, and here and there occurs a non-lignified passage-cell. When present, such a cell usually occurs opposite to a protoxylem-group, but they are rarely developed, the endodermal cells opposite the protoxylem being generally quite as densely lignified and thickened as elsewhere. Not infrequently the endodermis is locally doubled; this occurs generally immediately distally to the closure of the gaps in the central cylinder.

Between two inrolled edges of the fibrous zone, just before fusion takes place, the parenchymatous cells of the ground-tissue are often greatly crushed, and their lumina may even be entirely obliterated, showing that a differential rate of expansion has taken place since the procambial tissue was laid down in the apex.

Similar crushing may also occur between the nearly fused internal edges of greatly inrolled arcs of the fibrous zone. Some of the segments of the central cylinder are very small and may contain as few as one xylem- and two phloem-groups, the endodermis only bounding the peripheral surface. Others contain three xylem- and five phloem-groups; others are more extensively provided with endodermis investment. In the medullary tissue run isolated strands of fibrous tissue, many of which possess a xylem-group consisting of one large vessel and two or three smaller ones. In other cases only the large vessel is present. In one case an interesting condition was observed in the presence of a phloem-group, quite unaccompanied by xylem, running just internally to a gap in the fibrous zone. Occasionally a medullary fibrous strand may enclose a central large vessel from which protoxylem-groups to the number of 3–5 radiate, alternating with which two or more phloem-groups occur.

At some gaps in the fibrous zone, even when the endodermis is complete across the gap, a line of cells of endodermic nature extends inwards into the cylinder. (Text-fig. 18.)

Fig. 18.



One greatly incurved arc of the central cylinder was found to be completed in a curious fashion. A medullary strand possessing three symmetrical protoxylem-groups radiating from a central vessel, and alternating with the protoxylems, approaches distally to the interior of the incurved arc and closes the gap by fusion of the fibrous tissues, thus enclosing a central parenchyma continuous above and below with the medullary ground-tissue. Of the three protoxylem-groups, two become arranged tangentially in a straight line, the third, pointing inwards, is considerably reduced. The endodermis is only incomplete at the most internal point of the cylinder thus formed.

Another interesting condition was observed where a complete cylindrical portion of the central cylinder is approached distally from the interior by a medullary strand, with four xylem- and four phloem-groups, which eventually fuses with it, thus causing a very irregular arrangement of xylem and phloem on the interior of the composite cylinder so formed. On following this cylinder distally, the ordinary symmetrical alternation of xylem and phloem is gradually attained, and thus a cylinder is produced with four more xylem-groups than the original one.

Lower down in the root this opens internally and its central parenchyma becomes continuous with the medullary parenchyma, and finally, traced to the apex, the group is represented as a distinct, curved, procambial strand, consisting of xylem- and phloem-groups embedded in fibrous ground-tissue.

The internal fibrous strands which contain xylem and phloem tend to fuse with the peripheral system of the cylinder. In those strands possessing only a single central vessel no such tendency manifests itself, these being continued as separate procambial strands into the apex.

On following the separate arcs of the cylinder towards the apex, they are seen to open out internally and finally to unite, gradually losing the lobed outline, and eventually forming a complete uninterrupted meristematic cylinder. Sometimes where fusion of the arcs takes place the endodermis is doubled.

Only in a long root can all these changes be observed; in shorter roots the reduction to normal root-structure is incomplete. Only a very small proportion of the roots examined showed complete simplification. The union of the arc is always completed earlier (*i. e.* more proximally) on the abaxial than on the adaxial side, a single gap in the fibrous zone often persisting for a very considerable distance on the adaxial side after the cylinder is otherwise complete and regular. Occasionally small groups lying well to the interior of the cylinder are externally provided with endodermis.

(46) CYRTOSTACHYS RENDA, Blume.

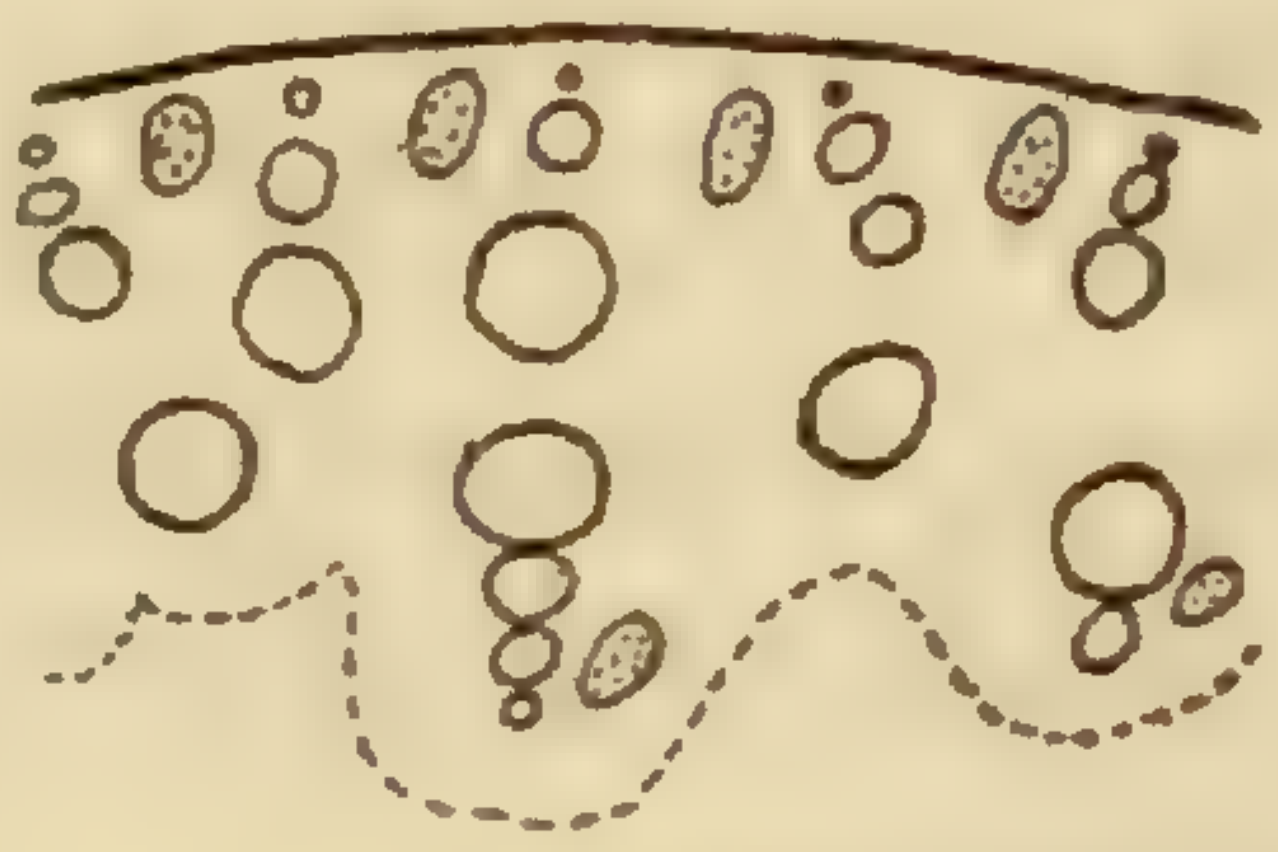
The limiting and subjacent layers are of the usual type, and are followed by a closely packed parenchyma with mucilage-canals, and this again by the loose layers of the cortex, with their air-spaces and bundles of fibres, which are shorter than usual, and belong rather to the *Kentia*-type than to the more elongated, narrow type of *Oreodoxa* and *Raphia*. Individual elements of the same nature occur in the zone immediately surrounding the endodermis. The endodermis is lignified, and is followed by a one- or two-layered pericycle.

The fibrous zone of the central cylinder is broad, and generally each protoxylem-group has its own one, two, three, or more large internal vessels. Some of the protoxylem-groups are, however, without internal vessels. V-formation is not well shown. The central medulla possesses fibrous bundles and air-spaces like those of the cortex. Three or four bays of fibrous tissue project into the pith, and nearly form free medullary strands.

In large roots the fibrous zone is incomplete on one side, and the incurved edges are followed by the endodermis more deeply than usual; the endodermis is, however, finally lost in the common ground-tissue.

An interesting feature in this root is the occurrence of two strongly inwardly projecting bays of fibrous tissue in which the protoxylem is well developed internally and accompanied laterally on one side by a phloem-group (text-fig. 19).

Fig. 19.



In other cases this internal xylem is disappearing, the smaller elements having quite aborted, leaving only the small metaxylem-group abutting on the large internal vessel. In other cases, again, only the large internal vessel persists. Thus some of the large internal vessels of these roots undoubtedly represent the remains of what were originally inwardly directed xylem-groups.

(47) PTYCHOSPERMA PERBREVIS, H. Wendl.

Immediately beneath the normal limiting-layer is a zone of three or four fibrous elements lignified and thickened and with transverse walls. Then follows a zone of extremely densely thickened and pitted fibres. The inner cortex is parenchymatous, and is provided with definite bundles of fibres with small lumina and also with some less thickened fibres generally running singly. In the internal portion of this cortex are air-spaces. Through this region run ducts, containing much mucilage and some crystals of calcium oxalate. The endodermis is of the usual thickened and lignified type. The central cylinder is normal and uninterrupted; a broad zone of parenchyma contains the xylem and phloem peripherally. Only one ring of large internal vessels is present. Centrally there is a parenchymatous pith containing some lignified elements.

(48) PTYCHOSPERMA MACARTHURI, H. Wendl.

The cortical tissues are very similar to those in *P. perbrevis*. The central cylinder is very greatly broken up as in *Kentia*, but there is still more strongly marked inrolling of the separate arcs. Internal fibrous strands are present, but are few in number. Each contains a central vessel, in one case accompanied by a phloem-group. The medullary and cortical tissues are quite continuous, and similar bundles of fibres are present in each.

(49) PTYCHOSPERMA FILIFERA, H. Wendl.

The limiting-layer is, as usual, composed of isodiametric cells with thin lignified walls. This is followed by a narrow zone of elongated cells with slightly lignified walls and dark mucilaginous contents. In the parenchymatous cortex occur bundles of fibres and air-spaces. The endodermis is of the usual lignified type; the pericycle is one cell thick.

In a small root all the elements of the fibrous zone are not yet lignified. The pith is represented by a few parenchymatous cells. A very great tendency to V-formation obtains in this root. Out of fourteen protoxylem-groups twelve are arranged as V's with six internal larger vessels. The other two groups, which occur at either end of a diameter of the cylinder, are in conjunction each with its own large vessel. It is impossible to say whether this diametrical arrangement has any morphological significance, since the orientation with regard to the stem could not be determined.

In a larger root a considerable pith occupies the centre and is surrounded by a comparatively narrow fibrous zone. Here again V-formation is very strongly marked. This root differs from all other palm-roots examined in the fact that to each protoxylem-group there is a considerable number (often four or five) of larger vessels, two of which are often placed tangentially. In some cases three of these groups may join tangentially, producing a xylem-band connected externally with three protoxylem-groups. Such a formation is usually followed laterally by V's with extensive internal xylem-groups, and in this way a nearly complete xylem-ring may be formed with exarch protoxylem-groups between which lie the rounded phloem-masses.

The pith contains bundles of lignified elements, in transverse section looking very much like fibres, but seen in longitudinal section to be short and square-ended. Two groups of fibrous tissue, each enclosing one large and several smaller vessels, occur in the pith. In these large roots the contour of the cylinder is slightly lobed, but no complete gap was observed.

(50) PTYCHOSPERMA CUNNINGHAMIANA, H. Wendl.

The limiting-layer is as normal, and is followed by the usual small elongated elements, and these again by a parenchymatous cortex through which run lignified fibrous elements, but no definite fibrous bundles. The inner part of this cortex has fairly regularly developed air-spaces, and here there is a tendency to grouping of the fibres into bundles. The endodermis is of the usual lignified type. The pericycle is generally one cell thick, but occasionally it is doubled. There is a well-developed fibrous zone in which the xylem and phloem are embedded. V-formation is not infrequent. An interesting feature is the presence of two or three small vessels interior to the large internal elements. The pith is large and parenchymatous, with small air-spaces and fibres like those of the cortex.

(51) DICTYOSPERMA ALBUM, H. Wendl. et Drude.

The limiting-layer is normal, and is succeeded by a zone of lignified elongated cells with dark mucilaginous contents. This again is succeeded by a zone of fibrous elements among which are scattered some parenchymatous cells; more internally the parenchyma very greatly preponderates, and the fibres are here arranged in definite bundles, very abundantly developed. In this zone small irregular air-spaces occur. The endodermis is lignified.

The pericycle is one- or two-layered. Inside this lies a zone of lignified thick-walled fibres in which are embedded the xylem and phloem. The vascular elements occupy only the periphery of the central cylinder. V's are occasionally found in the xylem, but not in the phloem. A few medullary strands of fibrous tissue, containing one large vessel, sometimes accompanied by one or two smaller ones, generally occur. In the pith some individual fibres are present, but no fibrous bundles like those of the cortex.

Proximally a gap in the cylinder is present and the edges are rounded off and inturned; the endodermis follows these and is finally lost in the ground-tissue, being thus incomplete across the gap.

The latest gap to close up is on the adaxial side of the cylinder. In this region there is greater development of the medullary fibrous groups with central vessels, as well as greater central extension of the large vessels of the cylinder.

Still more proximally the cylinder is more strongly lobed.

(52) PINANGA sp.

The limiting and tegumentary layers are developed as usual. In the external layers of the inner parenchymatous cortex are individual fibres, resembling those generally occurring in very definite strands. More internally fibrous strands of the type found in *Kentia* occur. The endodermis is lignified and the pericycle one-layered. A comparatively narrow, but very definite fibrous zone contains the xylem and phloem. V-formation is not often found, but is very well shown when it does occur. In the pith occur strands of fibres like those of the cortex; air-spaces and mucilage elements with dark contents are also present.

(53) PINANGA KUHLII, Blume.

The external layers agree generally with those in the last species. The air-spaces of the inner cortex are, however, much larger and more definite. The endodermis and pericycle are similar, as is also the fibrous zone. Only one ring of internal vessels occurs, and they are comparatively small and peripherally situated, and the protoxylem-groups are widely separated. V-formation is unusual, but is found occasionally. Two groups of fibrous tissue were found in the pith, and a third not quite free from the fibrous zone, each with a single internal vessel.

In the pith are mucilage-spaces and bundles of fibres.

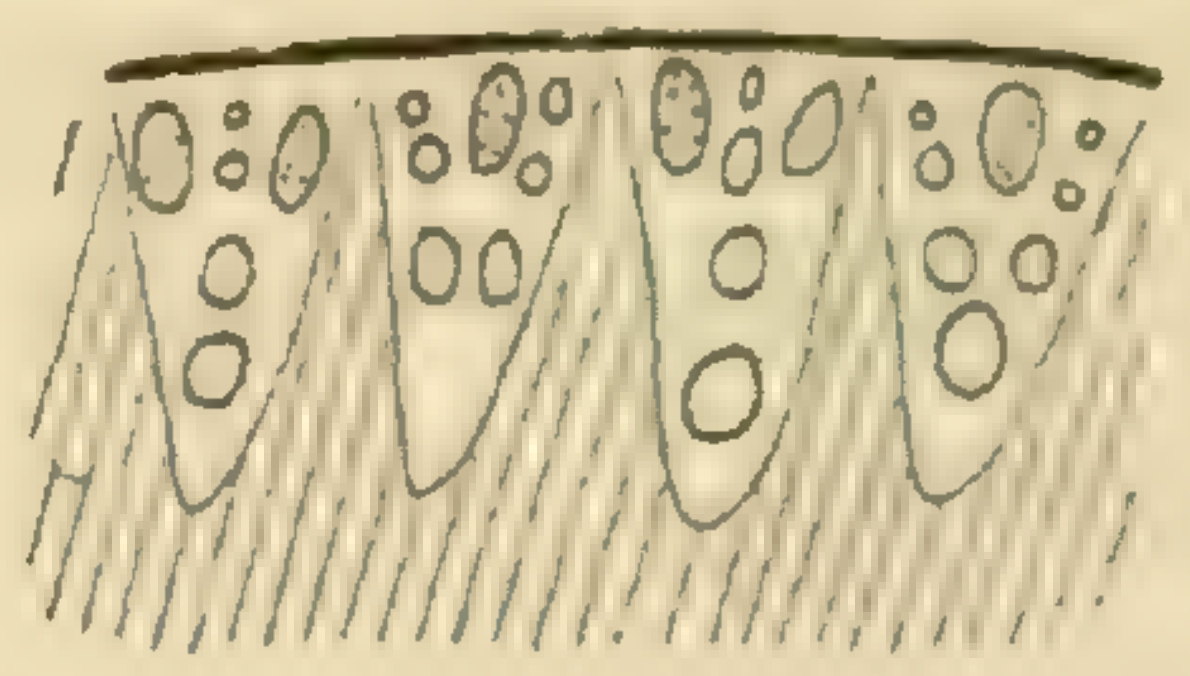
(54) Areca Catechu, Linn.

(i.) *Small root.*—The limiting-layer is, as usual, followed by elongated elements with dark contents, and these again by a parenchymatous cortex. The outer part of this is without air-spaces, but contains lignified elongated elements, with comparatively large lumina, and more internally bundles of fibres also occur. In the inner layers of the cortex are many large air-spaces in several irregular rings, and in the parenchyma enclosing these are large bundles of fibres. The endodermis is lignified and the pericycle is two layers in thickness. The fibrous zone in which the xylem and phloem are embedded forms a series of bays projecting into the pith. The xylem-elements extend some considerable distance centrally, and most of the large inner vessels can be definitely brought into line with the protoxylem-groups. **V**'s are often formed, and two protoxylem-groups may form a **V** with the outer of three internal vessels, thus giving a well-marked **Y**. In the pith are some fibrous elements like those of the outer cortex.

(ii.) In larger roots the pith is much more extensive and the fibrous zone relatively narrower. The internal vessels are more scattered and generally lie in sets of two or three, or one or two large ones may be accompanied by two or three smaller ones. Into both large and small vessels well-developed thyloses project.

(iii.) In still larger roots, or in sections more proximally placed, the central cylinder has a slightly lobed outline. The xylem- and phloem-groups usually lie in threes, two xylem-groups or a xylem **V** and a phloem-group, or one xylem-group and two phloem-groups, being embedded in wedge-shaped masses of fibrous tissue, whose apices project centrally. The wedges are separated from one another by extensions of the medullary parenchyma extending as far as the pericycle (text-fig. 20). The medulla is parenchymatous, and in it are bundles of fibres similar to those of the inner cortex.

Fig. 20.



The cylinder is incomplete at one point, and here the endodermis dips in and is lost internally, the medullary and cortical parenchyma being continuous. Opposite to the gap is a group of fibrous ground-tissue enclosing two vessels.

(iv.) In still more proximally situated sections the lobing of the central cylinder is more extensive and several gaps are present. Opposite each gap is an internal fibrous strand with vessels and in some cases phloem also.

(v.) In other sections much greater splitting of the central cylinder is shown, the fibrous zone being composed of a number of separate arcs of varying size, the ends of which are incurved and accompanied by the endodermis, which is eventually lost in the ground-tissue. In the smaller segments the fibrous tissue is more and more infolded, until in some cases it fuses internally and a complete ring is produced, only lacking endodermis on its central surface. Finally a complete endodermis occurs round one such cylinder, which lies outside the general fibrous zone. Just internal to it is a gap in this zone, and it would appear that this portion of the central cylinder has failed to establish complete continuity owing to a portion of the zone having extended too far peripherally, this latter having formed a cylinder on its own account, leaving a gap in the normal ring. The excentric cylinder has eleven xylem-groups with two **V**'s and eleven phloem-groups. It gives off a lateral root, and behaves in all respects exactly like an ordinary root-cylinder. Below, this structure passes into the normal root-cylinder by a method illustrated in Pl. **51.** figs. 99 to 102 and fully described above.

The medullary parenchyma in this region contains masses of fibrous tissue with central vessel or vessels and sometimes also phloem.

(55) ARECA CONCINNA, Thw.

The limiting and tegumentary layers are like those in *A. Catechu*, L.

The parenchymatous cortex is without air-spaces, or only with very small ones. In this zone occur mucilage containing parenchymatous elements. Small bundles of fibres are also present. The endodermis is lignified, and the pericycle one- or two-layered. The fibrous zone containing the xylem- and phloem-elements encloses a parenchymatous pith with mucilage elements. Xylem **V**'s are occasionally formed.

In the smaller roots the large internal vessels can be allotted to a single protoxylem-group or to a pair of such groups.

In larger roots the general arrangement is similar, but the xylem-groups are much more numerous and the internal large vessels are more scattered. Thyloses are abundant in the vessels.

In still larger roots xylem **V**'s and **Y**'s are abundant, and the xylem arrangement is irregular. The large central pith contains five or six fibrous masses, each with one or more vessels.

(56) ARECA sp.

On the surface is a layer of thin-walled limiting cells, followed by small elongated elements. The well-developed parenchymatous cortex is provided with strands of fibres and small scantily developed air-spaces. The endodermis is non-lignified and the pericycle is one-layered. The fibrous zone consists of wedges of tissue completely or nearly completely separated from one another by radiating extensions of medullary parenchyma. These wedges contain the xylem, usually one xylem-group to each wedge The phloem-bundles may lie laterally in the fibrous wedges or in the parenchymatous tissue between them.

On one side there is a more distinct break in the fibrous ring, and here the incurved edges carry phloem-bundles internally. The endodermis is slightly inflected, but is continuous over the gap. At such a point there is a tendency for the fibrous wedges to become free medullary strands. More proximally the central cylinder is broken up into arcs, and into the gap between each pair the endodermis dips in and is discontinuous. At these gaps some of the wedges are present as free medullary strands, and in the general medullary parenchyma are developing masses of fibres enclosing one or more vessels, and sometimes also a little phloem. Bundles of fibres similar to those of the cortex are also present.

Small and regular air-spaces occur in the cortex of these large roots.

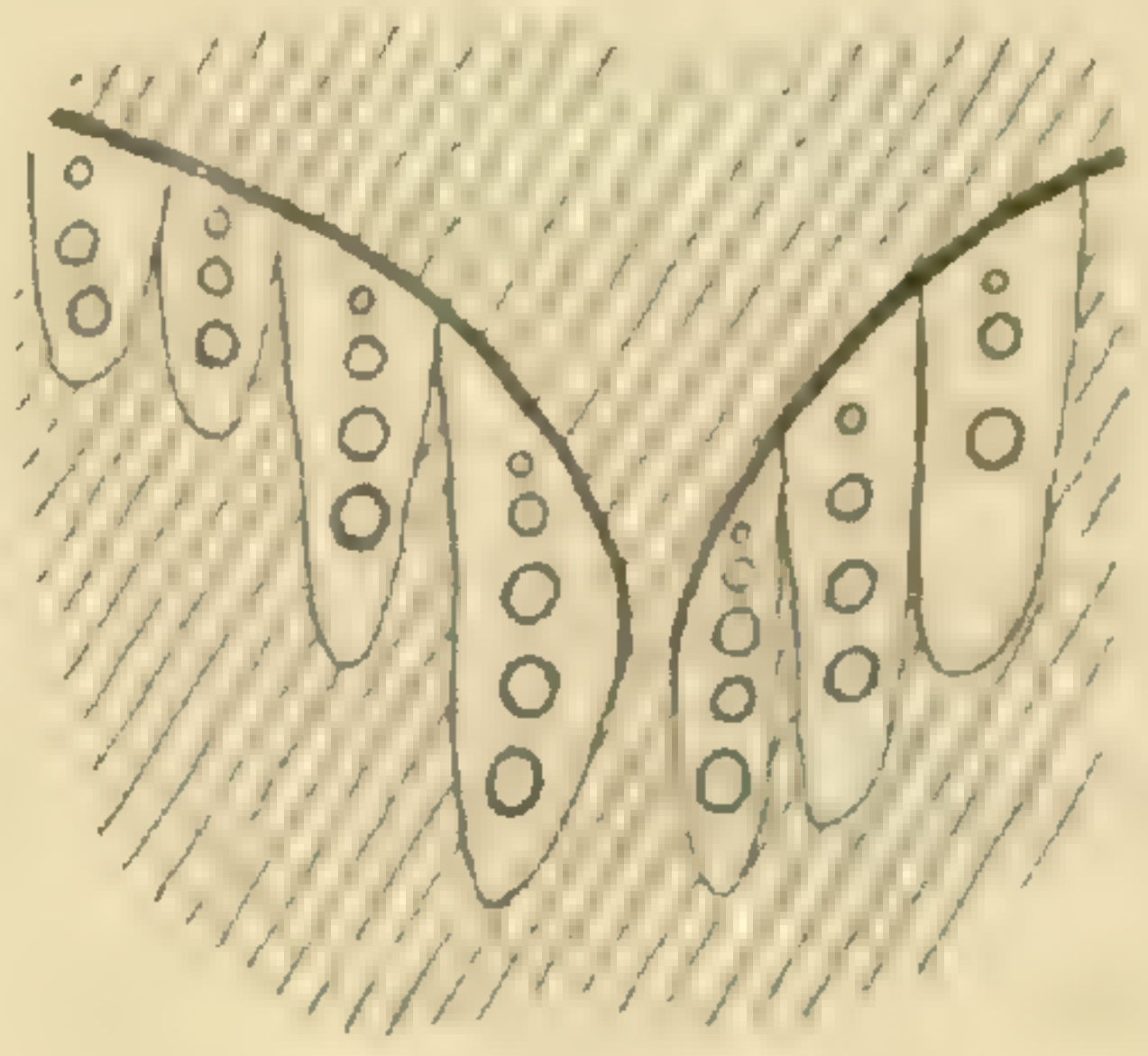
57. Areca sp. (from Glasgow).

These roots were only obtainable in small detached portions, and are described below under the headings *A*, *B*, and *C*, according to the type presented.

A. Limiting-layer and cortex are as in the last root. The endodermis is only partially lignified, lignification delaying longest opposite to the protoxylem-groups. The pericycle is one or two cells thick. The cylinder is quite complete for at least half its circumference, while the other half consists of a series of separate arcs, whose free edges are generally somewhat incurved, but in no case is the incurving very extensive. The fibrous zone consists of partially separated wedges in which lie the xylem, the phloem often lying in the parenchyma between two wedges. At the gaps there is often an insunk fibrous mass with a central vessel.

The xylem of the lateral wedges of the arcs shows a peculiar radial extension (text-fig. 21).

Fig. 21.



In some cases a fibrous strand may run in the interior with several vessels, quite independently of any gap in the cylinder. **V**'s are of frequent occurrence, and there is considerable metaxylem-formation which always favours such an arrangement. It is by the lateral approximation of these metaxylem-groups that the **V**'s are formed.

In the pith are bundles of fibres and some few air-spaces similar to those in the cortex.

B. The whole cylinder is composed of a number of small arcs, the ends of each being strongly incurved. The fibrous wedges which contain the xylem are almost entirely separated by parenchyma, and the xylem-groups of the ends of the arcs tend to point outwards as in the last case. Often between these arcs are found individual wedges which have not entered into arc-formation. Such wedges have externally developed endodermis, and may possess three or four xylem-groups accompanied by as many phloem-groups. Many internal fibrous strands are present with xylem and phloem, not in any way entering into the peripheral system of the cylinder. The most internally placed of such strands possess only a single vessel.

In this root the very great parenchymatous development is not accompanied by a corresponding development of the fibro-vascular tissue, and hence the separation of the fibrous arcs is much more marked than in any other root examined.

C. (Pl. **50**. fig. 76.) In this root the arrangement of the fibro-vascular tissue is very peculiar. On one side there is a large cylinder with continuous endodermis on the whole of that surface presented to the exterior of the root. The portion of this cylinder presented to the interior of the root is composed of a number of isolated small fibrous masses with endodermis on the surface nearest to the centre of the root. Each of these fibrous masses has a radially symmetrical development of xylem and phloem.

The fibrous tissue is throughout usually in the form of wedges.

In the parenchymatous tissue occupying the interior of this cylinder are many fibrous masses each with xylem and phloem generally radially arranged in several groups.

Accompanying this incomplete cylinder are three complete cylinders, round each of which the endoderm is continuous. The whole arrangement in this root is of great interest as bearing on the question of the morphological value of medulla and cortex in these organs. The general ground-tissue in which the cylinders are embedded is provided throughout with well-developed bundles of fibres and air-spaces.

(58) Cocos PLUMOSA, Hook.

The tegumentary layers are normal. A thin-walled layer of isodiametric, slightly cuticularized cells is followed by a more than usually broad zone of small elongated elements, only slightly lignified, and this again by the parenchymatous inner cortex with small and very irregular air-spaces.

Immediately surrounding the endodermis is a narrow zone of thick-walled and pitted stone-cells. The endodermis is lignified, and the pericycle two cells in thickness except just opposite to the protoxylem, where it is reduced to one cell. Opposite the phloem the inner pericyclic cells are often considerably crushed, but seem to be always present. A broad zone of fibrous tissue carries the xylem and phloem and surrounds a central pith. There is a well-developed system of scattered internal vessels which do not extend to the inner margin of the fibrous zone. **V**-formation is very general by the approximation of two xylem-groups to the exterior of one large internal vessel. The phloem-groups vary greatly in outline, from small peripheral circular patches to radially elongated internally-stretching bands.

In larger roots the inner vessels are much more regularly arranged, usually in two rings. Others occur in fibrous masses distributed in the medulla. Some of these strands are connected externally with the fibro-vascular cylinder, but the majority are free.

In still larger roots the medullary fibrous groups are more abundant and more than one vessel may occur in each. Wedge-formation also obtains in the fibrous zone, which is interrupted by a wide gap on one side, the free edges being incurved. The asymmetry of the xylem-groups is here not so marked as usual, internally pointing protoxylem-groups being found.

The phloem, however, tends to retain its outward orientation. Just inside the gap are two little cylinders, with xylem and phloem radially arranged, one being almost completely surrounded by endodermis. The other little group, which lacks internally arranged protoxylem, lacks also internally developed endodermis.

(59) Cocos Romanzoffiana, Cham.

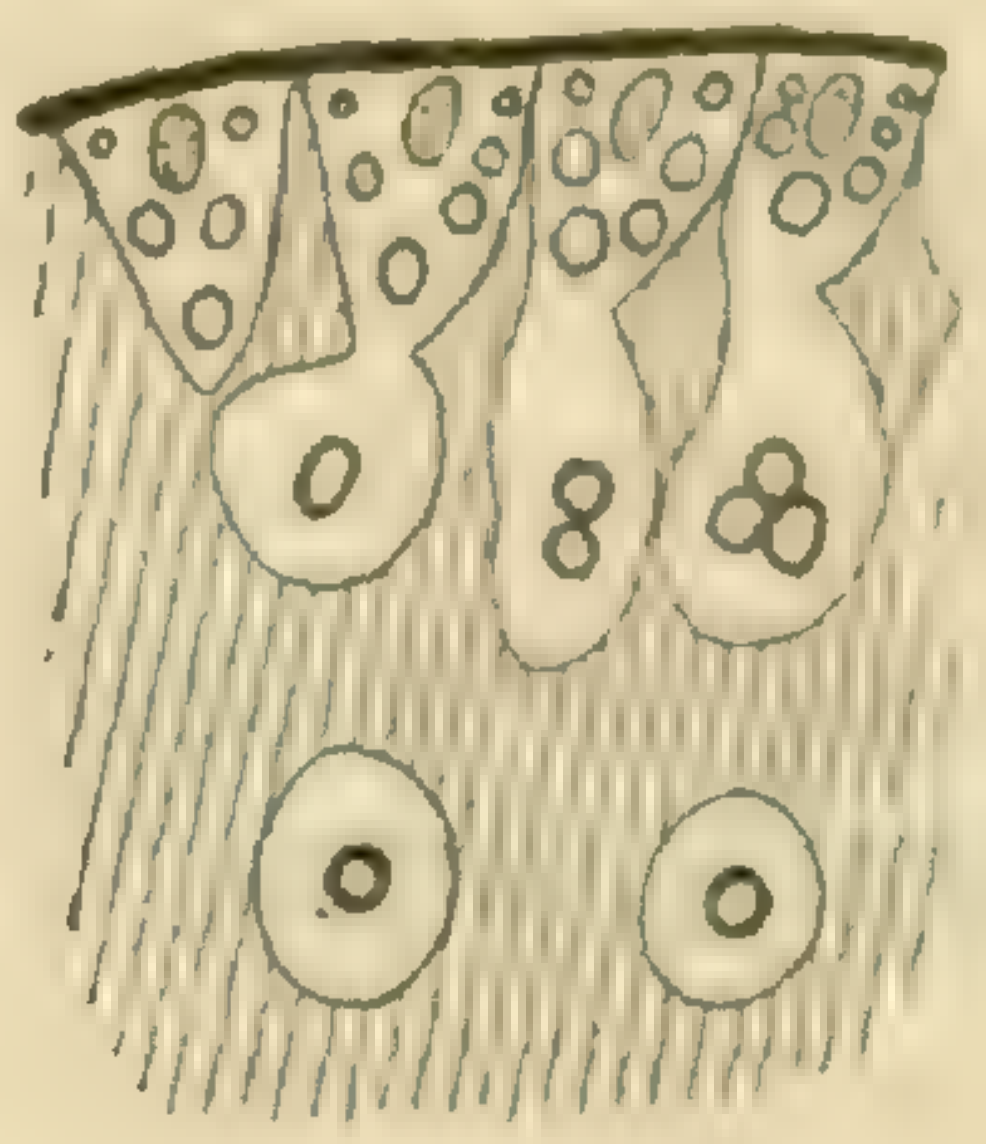
Essentially similar to *C. plumosa*, Hook.

(60) Cocos flexuosa, Mart.

The small roots are essentially similar to those of *C. plumosa*, Hook., and *C. Romanzoffiana*, Cham. In larger roots the cylinder is incomplete on one side, the free edges being incurved, and at this point there is no protoxylem, a single vessel representing the xylem-group. Into the medullary tissue opposite to a gap a fibrous mass, containing one large vessel and several phloem-groups, is sunk.

In the centre of the pith are several fibrous strands, each with one, two, or three large vessels. The fibrous zone is here much less regular than usual, consisting of partially separated wedges, united internally with other fibrous groups containing several vessels, but without protoxylem. (Text-fig. 22.) These enclose among themselves little groups of parenchyma, shut off from the pith by the growth of fibrous tissue. Many of the larger vessels contain thyloses consisting of pitted parenchymatous cells. Similar to these are large cells, staining yellow with aniline chloride, occupying irregular spaces in the pith. They are almost certainly formed in the same manner as the "thyloses" described in the cortical air-spaces of *Areca concinna*, Thw.

Fig. 22.



(61) Cocos botryophora, Mart.

The outer part of the parenchymatous cortex is comparatively broad and is without air-spaces. Through the inner part run irregular small air-spaces. Scattered throughout the cortex are isolated, somewhat elongated and lignified parenchymatous elements, with square or rounded ends. Just external to the endodermis is a specially well-developed layer of these, some few of which are thinner-walled and isodiametric. The endodermis is lignified and followed by a two-layered pericycle, which becomes one-layered opposite to the protoxylem.

The fibrous zone consists of a series of wedges, continuous with one another at the periphery, but free internally. Xylem **V**'s are frequently developed.

Many internal fibrous groups connected with the inner extremities of the fibrous wedges occur, each containing a single large vessel.

Some free medullary fibrous groups of the same nature also occur in the well-developed pith.

(62) Cocos nucifera, Linn.

The tegumentary layers are of the usual type, but greatly indurated. In the outer zone of the parenchymatous cortex are abundant mucilage reservoirs, containing mucilage of a brown colour and raphides. More internally are regular small air-spaces.

The lignified elements of the cortex, consisting of small, square stone-cells, are almost confined to a zone immediately external to the endodermis.

The endodermis is lignified; the pericycle is two cells in thickness, but frequently interrupted. There is a broad, greatly indurated, fibrous zone in which the xylem and phloem are embedded peripherally.

There is only one ring of large internal vessels. A medullary strand of fibrous tissue, with a single internal vessel, is present in the small pith.

In a larger root air-spaces are well developed in the inner cortical layers, but are very irregular, and lignified elements are more generally distributed. Internally is an extensive pith, with large and very regular air-spaces.

(63) Diplothemium maritimum, Mart.

The limiting-layer is normal, and is succeeded by elongated elements with pitted walls, which give place internally to longer and less lignified fibrous elements.

These become more parenchymatous internally, and finally pass into the parenchymatous inner cortex, with its small, irregular air-spaces. Throughout this region occur small lignified parenchymatous elements, particularly richly distributed just outside the endodermis, where they form a more or less definite zone. In this zone the elements are true stone-cells. The endodermis is lignified, and the pericycle consists of two layers of lignified and pitted cells. The fibrous zone is fairly broad, and contains the considerably extended xylem-groups and the large internal vessels arranged in one irregular ring, with a few vessels still more internally placed. The phloem-groups are also greatly extended radially, generally as far as the internal limits of the xylem-groups. The central medulla contains many fibrous strands, each with one central vessel. Sometimes two of these strands run in contact with one another, and occasionally they are connected externally with the fibrous zone.

(64) Martinezia caryotæfolia, H. B. & K.

The limiting-layer and tegumentary layers are normal. The parenchymatous cortex possesses a system of irregular air-spaces and bundles of fibres, each bundle being provided externally with longitudinal rows of stegmata. Individual lignified parenchymatous elements are also found in these regions and form a specially developed layer around the endodermis. The endodermis is lignified and the pericycle is one-layered. A broad zone of fibrous tissue contains the xylem and phloem. **V**-formation occurs occasionally, but usually there is a large internal vessel to each protoxylem-group.

In a larger root the arrangement of internal vessels is more irregular, and xylem **V**'s and **Y**'s are of frequent occurrence.

(65) MARTINEZIA LINDENIANA, H. Wendl.

The cortex is generally similar to that of *M. caryotæfolia*. The bundles of fibres with stegmata are present, but the individual lignified elements are wanting, though the whole cortex is more or less slightly lignified. The air-spaces are very definite and are arranged in several irregular circles. The endodermis is lignified. There is a broad fibrous zone composed of extremely densely lignified and indurated fibres, whose lumina are almost occluded. This zone encloses a central parenchymatous pith provided with some lignified elements. The xylem- and phloem-groups are quite normal, with occasional V-formation in the xylem.

In large roots bundles of fibres occur in the cortex, and a zone of lignified stone-cells immediately surrounds the endodermis. A number of fibrous groups, with one, two, or three vessels, traverses the pith.

(66) BACTRIS MINOR, Jacq.

The external layers are as usual. The inner cortex is provided with irregular air-spaces. Stone-cells occur in a zone surrounding the endodermis, and scattered lignified elements are found throughout the cortex. The endodermis is lignified and the pericycle is two-layered. The fibrous zone is nearly filled with vascular elements. The large internal vessels occur in two rings, and the individual elements are closely packed and laterally flattened. Xylem V's and Y's are abundant. Internally there is a pith with large air-spaces.

V. PHYTELEPHANTINÆ.

(67) PHYTELEPHAS MACROCARPA, Ruiz et Pavon.

The cortex is entirely parenchymatous, without any lignified elements or fibres. Somewhat irregular air-spaces are present. The endodermis is lignified and the pericycle one-layered.

A broad fibrous zone encloses a central pith.

The protoxylem-groups extend inwards for a long distance, and generally each is provided with two or more large inner vessels. Occasionally these are accompanied centrally by one or two smaller vessels. The vessels are closely packed laterally and are flattened. The phloem-groups extend inwards nearly as far as do the xylem-groups.

EXPLANATION OF THE PLATES.

PLATE 48.

Fig. 1. Longitudinal section of stem of *Kentia* sp. showing origin of root.
2. Diagram of do.
3. More advanced apex of young root.
4. Group of cells in cortex of stem, in front of advancing root-apex. (See text.)
5. Longitudinal section through the common initial group in meristem of apex of *Areca*.
6. Diagram of apex of root of *Areca*.

Figs. 7–10. Transverse sections of apices of roots showing progressive changes in the procambial tissue.

Fig. 11. Apex of root of *Kentia* sp. showing root-cap.
12. „ „ *Iriartia* sp. „ „
13. Longitudinal section taken a short distance above the apex of the root in *Kentia*, showing root-cap and "epidermis" or limiting-layer extending below root-cap.
14. Longitudinal section of root of *Kentia* sp. showing the very thick-walled cells of the root-cap and an irregularity in the limiting-layer.
15. Transverse section of outer layers of root in *Caryota ochlandra*.
16. Transverse section of outer layers of root in *Phœnix sylvestris*, showing lignification proceeding both centripetally and centrifugally.
17. Transverse section of outer layers of root in *Dypsis madagascarensis*.
18. Development of air-space in *Kentia* sp.

Figs. 19 & 20. Air-spaces in *Kentia* sp.

Fig. 21. Air-spaces in *Phytelephas macrocarpa*.
22. „ *Metroxylon Sagu*.
23. „ *Iriartia* sp.
24. „ *Licuala gracilis*.

Figs. 25–27. Development of thyloses in air-spaces of *Areca Catechu*.

PLATE 49.

Fig. 28. Air-spaces in *Licuala spinosa*.
29. „ *Corypha australis*.
30. „ *Phœnix sylvestris*.
31. Tracheids in fibrous bundle of young root of *Dictyosperma album*.
32. Stegmata in *Raphia Hookeri*.
33. Stone-cells in cortex of *Sabal Palmetto* in longitudinal section.
34. Lignified elements in cortex of *Livistona australis*.
35. „ „ *Hyophorbe amaricaulis*.
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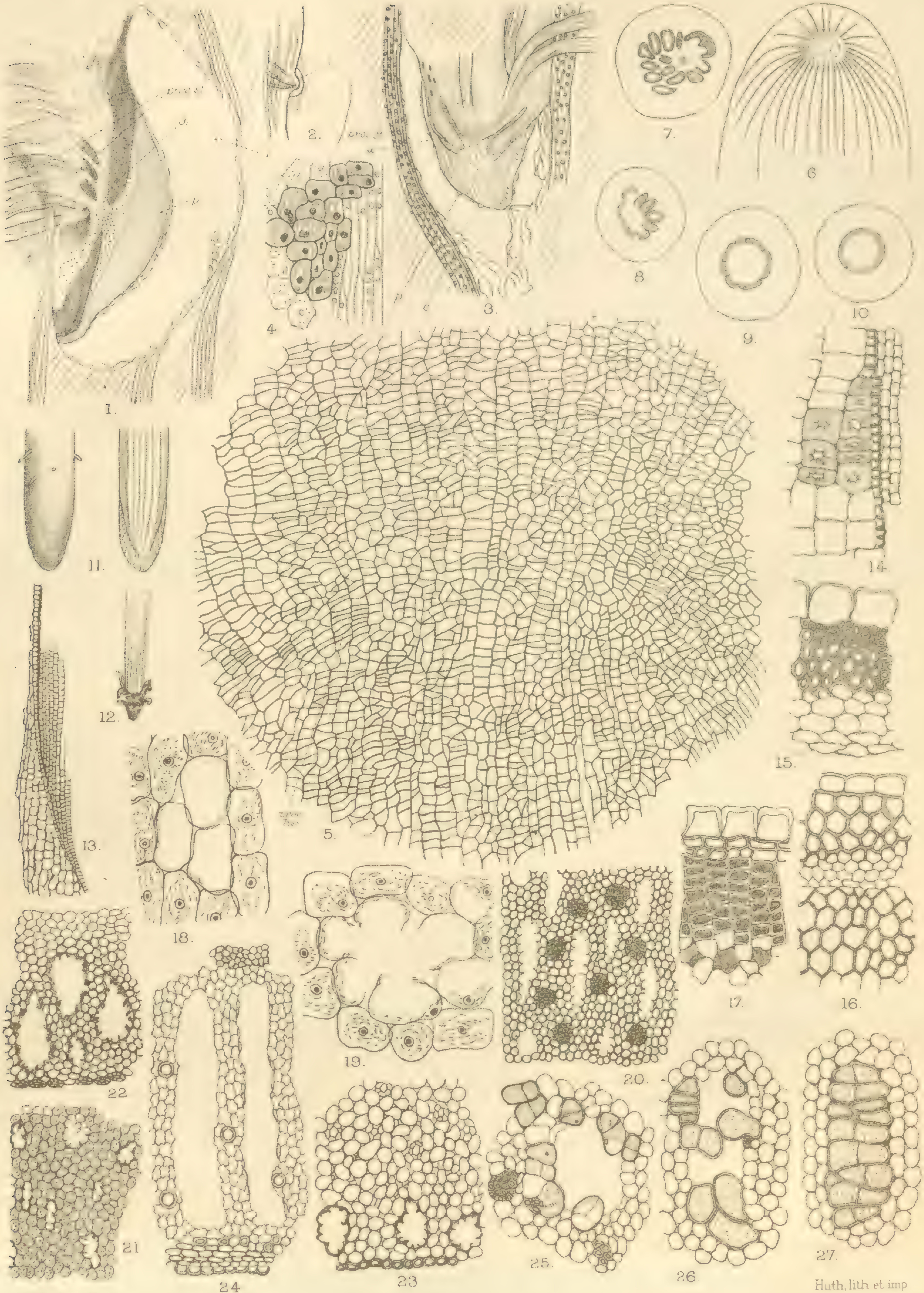
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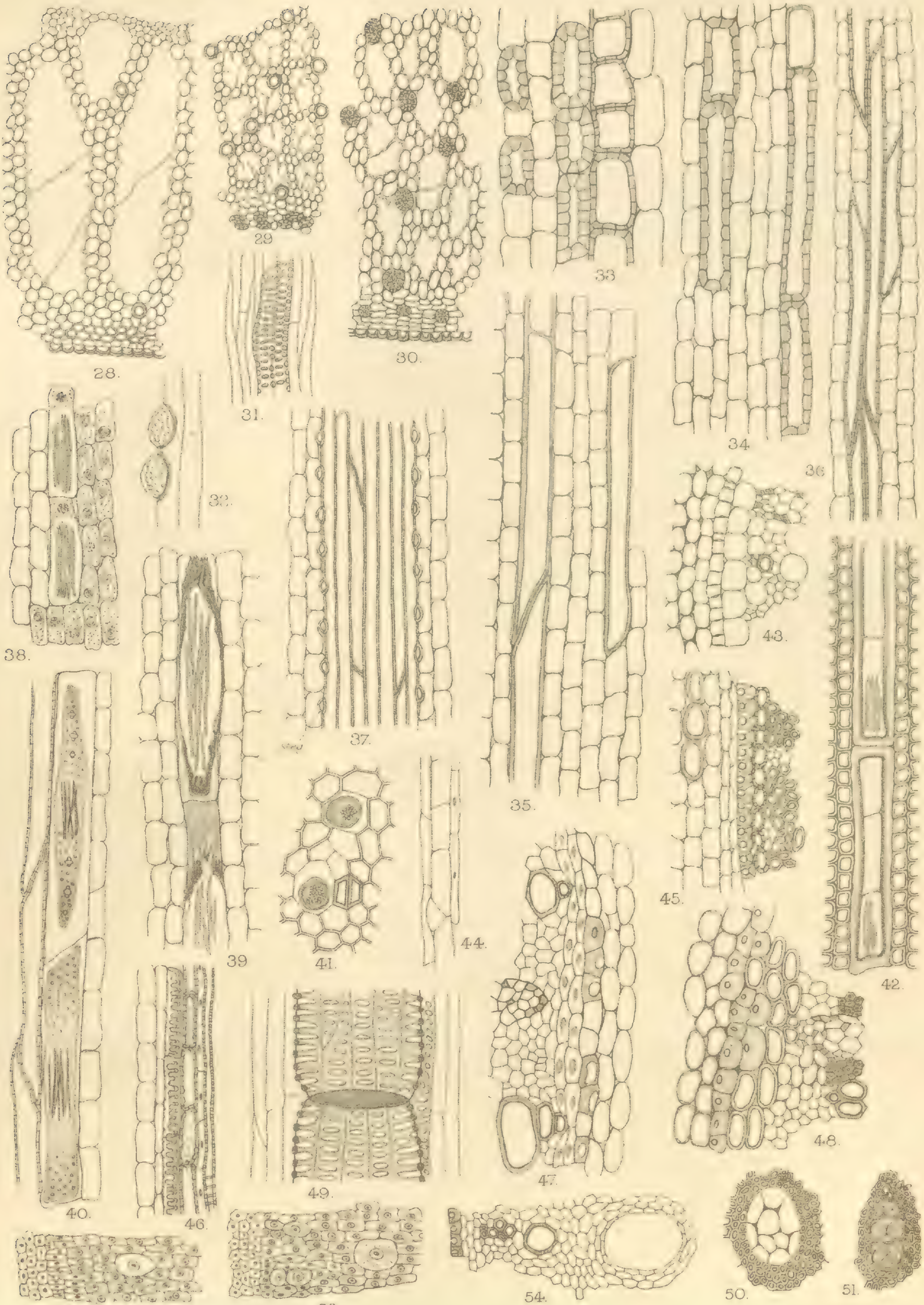
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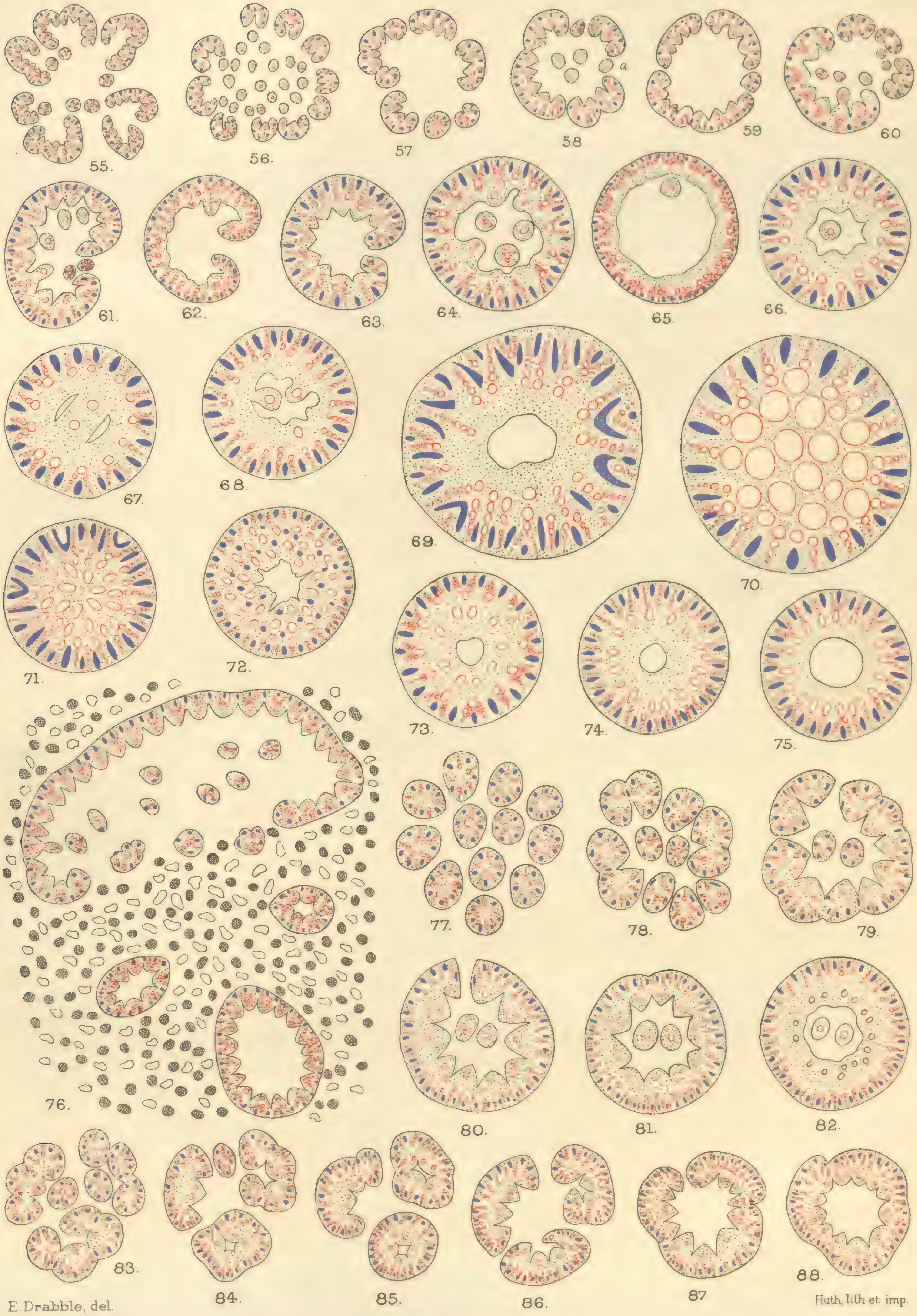
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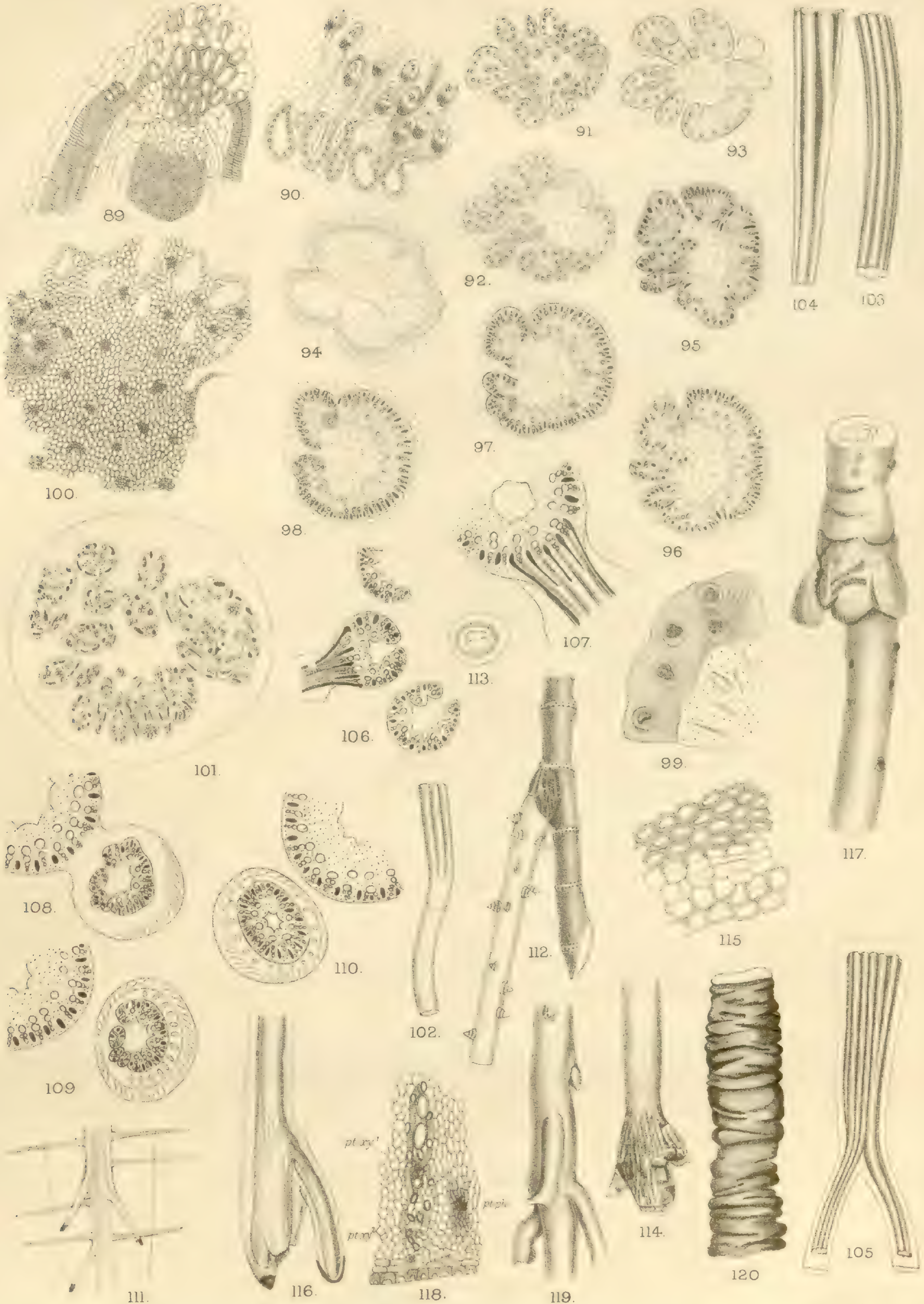
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